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DISCOVERY

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READING WITHOUT TEARS

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BLUEPRINT OF THE FUTURE OF SCIENCE

THE editorial of our January number discussed scientific prophecies; and now a book has appeared which makes all previous scientific prophecies look amateur, tentative and thin. It is called *The Social Function of Science*,* and is written by Professor J. D. Bernal, who is best known to scientists by his work on X-ray crystallography and particularly by his beautiful and decisive researches on the crystal structure of vitamin D, the tobacco mosaic virus, and proteins such as insulin. This book, his first important non-technical publication, is a survey of existing science and a plan—or rather series of plans—of how science could be used to make a better world. To review it as it deserves would need the greater part of a number of *Discovery*; since that cannot be done, there are just three things which ought to be said about the book as a whole. First, it should be read by anyone interested in science and the modern world. Second, it is often difficult to read, sometimes provocative, and occasionally lacking in human wisdom. Third, it is the work of a man of genius—using that word in a sense so restricted that it would include only a dozen or two men now living.

* *The Social Function of Science*, by J. D. Bernal. Routledge, 12*s.* 6*d.*

There is, however, one other special point. The book, as has been mentioned, is often difficult reading; and in order to get the full impact of Bernal's mind, it might well be best to begin with the remarkable section on the future of science. This section occurs as late in the book as p. 330 and goes on for fifty pages; it deals first with immediate prospects of science, and then with long-range possibilities; it is almost incredible that any one man should possess simultaneously this imaginative power and this technical knowledge of so many different scientific fields. (He is one of the last men of whom it can be said that he knows all science; which, at the present stage of scientific history, is a fantastic feat.) These fifty pages are the richest in conception of any scientific exposition ever done: they form a guide to the future, a detailed prophecy of the advancing front of science over ignorance, first in the next few years and then in the more distant future.

It is very easy to pick examples out of this prospectus: every page bristles with them.

On PHYSICS:

...The possibilities of new combinations of oscillating circuits are infinite. With a proper collaboration of mathematical and electrical ingenuity they can be made, to a larger and larger extent, to substitute for the operations of calculation. Already with such applications mathematics is becoming mechanized, but at the same time there is opened a new era of mathematical mechanism. These new mathematical physical methods can be used to control apparatus and machinery, not, as heretofore, in the mere transmissions of human will to machinery, but in actual substitutions for human observation and control. Already processes can be watched by an infra-red eye, and errors humanly unobservable can be picked out. We have before us the possibilities of a new mechanics in which human intelligence will be used primarily in the designing of the machine, whose operations will be completely automatic, self-regulating, and self-repairing, with the ultimate elimination of the necessity for machine minders.

On THE STRUCTURE OF MATTER:

...A large new branch of physics is appearing, linking up with chemistry and dealing with the structure of solid or liquid matter. The first stage of this is an examination of the atomic structure of existing forms of matter, which has already led to the understanding of the properties of technical materials—metals, ceramics, fibres, etc. The need for development along these lines lies in the possibility of creating new materials, not by blind experimentation, which will never produce anything radically new, but by the full use of structural theory with the aim of producing materials having any desired properties.

...What we require at the moment is a material as light as, if not lighter than, cork, strong enough to withstand wind-pressure, fireproof, and offering good insulation against heat and sound. These are not impossible requirements. Indeed, materials satisfying nearly all of them have been already prepared and it is almost certain that, with the development of aerogels, the problem can be satisfactorily solved.

(Readers of *Discovery* will note the resemblance to some of Mr Bryson's prophecies.)

On COLLOIDS AND PROTEINS:

...Now we are beginning to see that the colloid particle owes its existence to a certain degree of the same polymerization (or joining together of many molecules) that gives rise to fibrous substances such as cellulose and rubber. By far the most important of colloid substances are the proteins, whether in the form of globular molecules, fibres, or membranes. When we have solved the problem of proteins, including the explanation of their chemical activity as enzymes, such as yeast in fermentation or pepsin in digestion, we shall have gone far towards bridging the gap between living and non-living systems.

On BIOCHEMISTRY:

...The transition of medicine from a half-empirical, half-magical practice to an applied science began with the discoveries of bacteriology towards the end of the last century—but it has only begun. Bacterial and virus disease is an attack on the body from the outside; in all other diseases, and in many bacterial diseases as well, the chief factor is the faulty functioning of the body itself with respect to the balance of natural chemical substances. The knowledge of what these substances do in health and disease is the first step to rational control. The analysis of the conditions of diabetes and pernicious anaemia leading to the discovery of a specific substance and a cure requires to be extended to all other diseases. On the two major unsolved problems of disease, chronic sclerosis and cancer, which between them account for most of the deaths of old people, the attack is only beginning.

On GENETICS:

...Yet the core of life lies still deeper. All physiology and embryology lead up to the study of the cell nucleus which contains in itself the specific and inheritable characters of the organism. The discovery of the connection between the genes in the chromosomes and the unitary factors of inheritance will rank with the quantum theory as the major discovery of the early twentieth century, but it is still a Keplerian and not a Newtonian discovery. We know that certain spots of matter in a chromosome have a definite connection with certain groups of changes in a developing organism and ultimately with certain characters in the adult organism, but the nature of the connection between the two is completely obscure.

And again:

...With our new knowledge of genetics it is now possible to go back to the problem that Darwin stated but did not solve, the origin of species and their distribution in time and space. It is no longer the fact of evolution that needs to be established, but its mode of operation that needs to be analysed in detail. Long before these problems are solved, however, genetics furnishes us with another and quite independent means of modifying life through selective breeding and even by the creation of mutations. Since the invention of agriculture and the domestication of animals man has never acquired such control of organic development as the science of genetics now offers.

The later part of the prospectus deals with science applied to human needs; again a few quotations can speak for themselves.

On THE PRESENT STATE OF THINGS:

...The adequate supply of primary necessities would give some twenty to thirty years of added life on the average to each person in the world. This may sound extreme, but

it merely reflects the fact that no one draws plain inferences from the difference between the Englishman's expectation of life of fifty-five years and the Indian's of twenty-six.

On Food:

...An enormously increased extension of the cultivated area could be attained by fairly simple physical means through effective irrigation of desert lands and ultimately by the covering over of deserts and turning them into vast greenhouses. Another method is the agrotechnical method of Dr Wilcox and Professor Gerike, by which, by growing plants in water troughs containing chemicals, the yield is enormously increased. As much as 75 tons of potatoes or 217 tons of tomatoes have been produced per water acre.

It is, however, probable that before these methods pass into general practice the use of the higher plants, however intensively cultivated, as primary food supplies would be replaced by methods of using lower plants such as algae and fungi. The primary sources of food in the sea are the algae of the plankton; hitherto we have used this source only indirectly through the fishes who eat it. It should be possible to convert this indirect use of three-quarters of the world's surface into a direct one by deliberately growing plankton in the sea and harvesting it, although probably it would be more economical to produce food by a number of factories working in sunny districts for the continuous growing of algae. At one further remove food products might be synthesized by bacteria or even by the enzymes of bacteria. Ultimately all our food is contained in the materials of the air, water, and rocks, and if we used our reserves of coal, or even limestone, as basic food materials we should have enough for a population thousands or millions of times that which exists at present on our globe.

On The Supersession of Textiles:

...The new development in the study of fibres will make almost indefinite improvements in clothing possible. Already artificial silk has shown that in this respect nature could be very adequately imitated. But more radical improvements could come not so much from attempts to produce new types of fibres as by short-circuiting the whole method of clothes production through making clothes directly from porous plastic material rather than from spun and woven fibre. In this or in some other way the permanence of clothes and the necessity for repeated washing could be dispensed with, which would immensely simplify living conditions.

On Housing:

...The services attached to buildings have in the past only too often been afterthoughts; in rational architecture they will become essential parts. Given good insulating walls, the problem of heating houses entirely disappears. Indeed, even in winter, the heat generated by the inhabitants of the houses would require some method of cooling to get rid of it. To secure this degree of self-sufficiency, however, it would be necessary to devise a rational ventilation system which did not, as at present, take in air cold and send it out hot, but arranged for the outgoing hot air to warm the incoming cold air in winter-time and vice versa in summer. The domestic fire would then become of purely ritual importance.

...Considerable developments may be expected in the application to buildings of aerodynamic principles, the least of which would be the abolition of draughts. But it is beginning to be realized that with the appropriate use of properly shaped channels it is possible to maintain an opening secure against wind without the interposition of

any material. Thus the front windows of French express locomotives, which are particularly apt to become choked with oil and soot, have been replaced by baffle-guarded clear openings. A similar device may soon replace the automobile wind shield. In this way it might be possible to be able to have open windows summer and winter alike guarded either by the wind itself or by jets of air forming part of the general ventilating system. The ultimate development would be the weather-proof room without walls or roof.

On OLD AGE AND DEATH:

. . . The fatal diseases of old age are in a different category and offer the most immediate and serious challenge to science. Here success must go beyond nature, and this requires a very deep understanding of the processes of development and decay. Without that understanding we cannot even tell what is physically possible. It may be, or it may not be, possible to arrest that general hardening and drying of tissues which marks old age in all higher animals. It may be that rejuvenation or even regeneration of the body or of parts of it may be possible by means of the appropriate growth-promoting substances. The development of organ and tissue substitutes may serve to prolong life where only one part of the body is threatened. There is certainly hope that the problem of cancer, that most dreaded of diseases, is reaching a solution. What progress has been made, moreover, has been due to the collaboration of scientists in many different fields, but any really rapid and effective advance requires a far greater degree of co-ordination. It is idle to guess now how far death can be postponed for the majority by such measures, though it can hardly be to an age less than that of the oldest men now living. But it is a question which science can legitimately frame and attempt to answer. We do not even know in what sense death is an inevitable biological necessity or how far it is the shortest term of a series of pathological accidents, each one of which can be separately eluded. When we have found the answer to this we shall know whether the age of Methuselah is a fable or a legitimate aim.

And so this section, the most fertile fifty pages written since the War, goes on. It ought to be read with passionate attention. For, if man masters his political difficulties (and even in these grey days it seems certain that he must in time), most of this prospectus will come about.

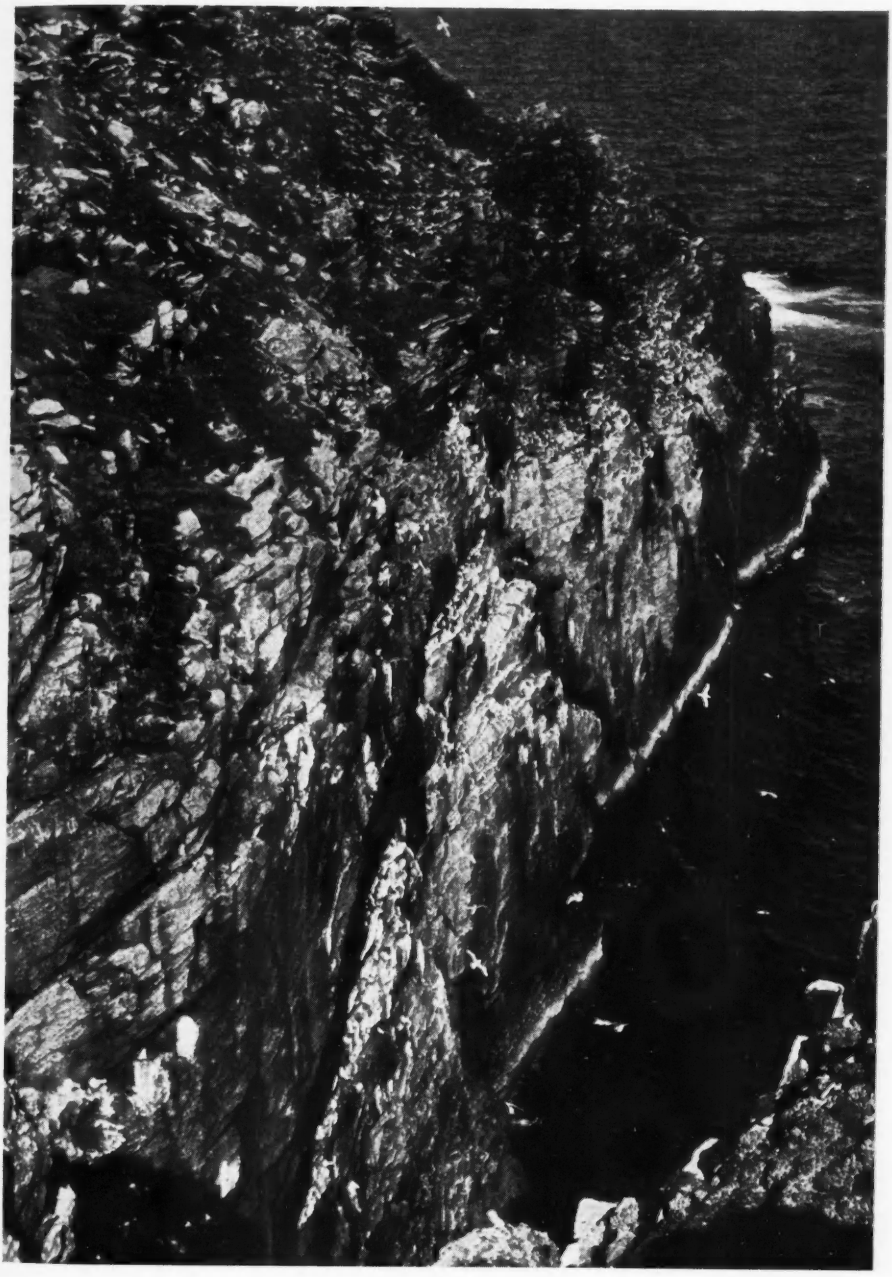
That, above all, we should remember. There are many futures, the futures of hope and fear and desire. Most of them are just compensations for our present state. To some extent, Bernal's is that too. But there is another quality about his vision. You can forget his idiosyncrasies and flaws and see something stronger and more lasting. In most men's dreams of the future, you take away the fears and desires and find nothing left, but in Bernal's you retain the deepest part. For his is the future of man's reason, and in the end, despite stupidity and wickedness and frailty, it will lay its hands upon the world.

I LIVED WITH →

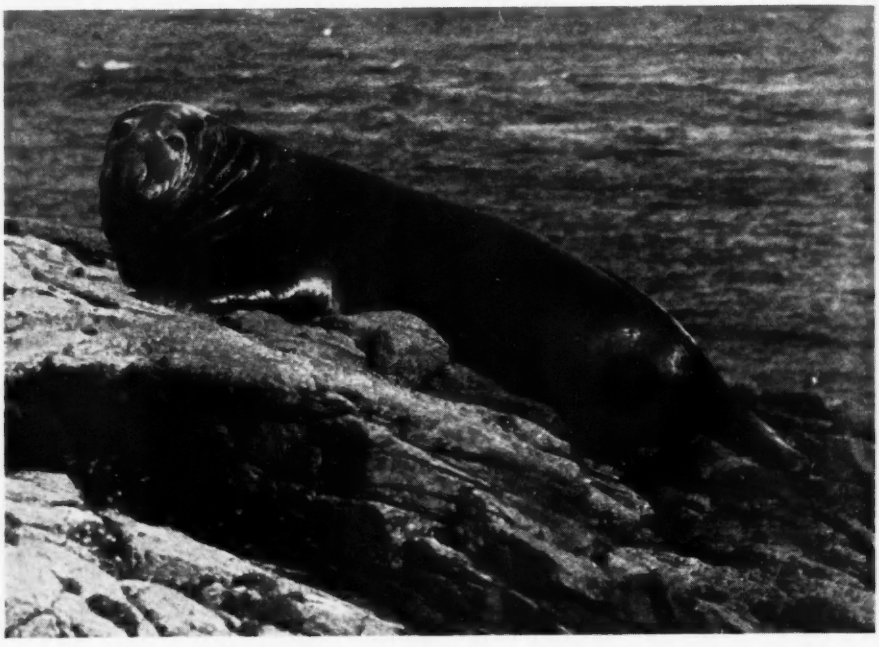
← SEALS

By F. FRASER DARLING, *who is back again in civilization after some months on the lonely island of North Rona. Dr Darling recently lectured on his scientific observations to the Royal Institution, and he and his wife were the subjects of television broadcasts from London.*

IN my last article on Rona in the November number of *Discovery* describing the great concentration of wild life on this North Atlantic islet of less than half a square mile, I did little more than touch on the life of the great herd of Atlantic grey seals which breeds there. Yet it was to study further the social life of this animal which took my wife and me to Rona. We had spent four months on the Treshnish Isles, west of Mull, in the autumn of 1937, and at the end of that expedition we felt we had a good story in our pocket, for the grey seal is the British mammal about which little definite knowledge has been recorded. One after another the natural history books have copied earlier errors. The expedition to Rona from July to December 1938 has confirmed what we learned on the Treshnish Isles, solved some puzzles, and supplied a mass of new data which was quite unexpected. One of the aims of my work on animal behaviour is to determine the



The west side of Rona. Some of the seal calves made their way down these cliffs to reach the sea



A fat, sleek bull, newly arrived from the sea—

influence of environmental factors on what animals do, and the most vivid interest to me in these two periods spent with the seals has been the comparison of their behaviour on coastlines of different types.

Lunga of the Treshnish Isles is an island of sheer cliffs sometimes falling direct to a shallow sea and sometimes to tiny shingle beaches and erosion platforms of laval rock more or less at sea-level. It was on these places that the grey seals came to breed and they could not, even if they wished, come up on to the green part of the island. The cow seals were constantly in and out of the sea, and the calves themselves were often to be seen swimming in the sheltered places when they were but two or three days old and still clad in the long white coat in which they are born. Although I was practically sure that the mothers did not feed when they were ashore for the season, while they were popping in and out of the sea I could not be absolutely certain. Similarly, I felt sure that the calves were weaned and left at a month old or possibly earlier, but with all the seals at sea-level and going in and out of the water, I hardly liked making definite statements. Another point which puzzled me completely was why we never saw any maiden cow seals on Lunga. Every cow that came ashore had a calf before mating—yet there is a first time for everything. Had I had a launch on the Treshnish Isles to go about regularly among the maze of skerries I might have solved the problem.

—goes inland and lies quiet in his chosen territory

Rona is completely rockbound, and though there is one flattish expanse of rock where the seals may come ashore, many of them climb up extraordinarily difficult places. Furthermore, the density of seals on Rona is great and the animals must go far inland.

This annual association of the Atlantic seals with the land is their time of greatest danger—danger from the licking surf and big tides and danger from predatory animals such as men—and their whole social system is beautifully adapted to lessening the danger. The metabolic processes of adults and young are also very different from those found in other carnivorous animals, and fit in with the social system to minimize the dangerous period ashore. The life of the grey seals at the breeding time is part of the drama of the sea's edge, a place where there is always conflict and reciprocation and something happening. Let us look into the story of challenge and response which is offered by the social life of the seals and their dangerous environment through the autumn months.

The bulls come to land in late August before the cows, but not in large numbers at first. The observer finds certain inaccessible ledges and skerries becoming occupied by more and more bulls lying cheek by jowl with each other and sometimes overlapping. These kind-looking, fat gentlemen do not quarrel; four or five hundred of them will lie together with hardly a sound or a scratch all through a sunny afternoon.

"Rocked in the cradle of the deep"

Then a few come farther inland to lie alone and quiet, often on the edge of some little brown pool caught up in the rocks. The few square yards round that bull comprise his territory. He will not go off to fight for more ground, he will not quarrel with his next-door neighbour, but if another bull comes up from the reservoir seeking a territory, there will be challenging behaviour and possibly a fight—and this long before any cows have entered the territories. There is a constant stream of fat, fresh bulls coming up from the reservoir throughout the breeding season, and spent ones are going down to the reservoir again. This traffic proceeds normally with comparatively little trouble, but if the seals farthest from the sea

The limit of the challenge; the next move is to fight—or retire

should be thoughtlessly disturbed by man, the frightened bulls will not go down to the water circumspectly, and before long the seal grounds will be in a state of uproar. This is just an example of how man may prove a serious menace though he may not be disturbing them intentionally.

Challenging behaviour is cheap, but actual fighting is biologically expensive. The bull seals, then, indulge in an interesting sabre-rattling display. If you look one full in the face you will see a strongly developed nose and upper lip; his teeth are quite out of sight. Challenge, therefore, consists of rolling first on one side, then on the other, and bending the head in the same direction as the roll. By this means the formidable canine teeth are visible to the opponent, and the hand is also raised menacingly. I had hoped to get a front-view portrait of a bull challenging, but I have been unlucky this year. I coaxed a bull into thinking I was another and he

came up showing his armaments; fine—I got all set; but when he came nearer he seemed to think I was rather scraggy and not worth challenging. He came open-mouthed and at six feet range I couldn't bear it any longer; I took the camera from my eye and sat up to show him I was a man. He seemed positively grieved at the deception, all the snarl went out of him. You can judge for yourselves whether I am right or wrong from his portrait.

The seals came in hundreds round our encampment, and all these soon got used to our presence so that we could move among them without causing any disturbance. Calves were born outside our very door, and sometimes I had to get up in the night to clear them out of some of the tinned stores we had lying under the remains of an old dinghy. As the seals of Rona have to climb up steep cliffs and come in some places as far as four hundred yards inland, they are unable to be constantly going in and out of the sea. I ascertained that the cows stayed ashore for periods varying from a fortnight to a month without any visit to the sea. They take no food in this time, but live on their large store of blubber and suckle the calf on milk which is more than a third fat. The cow, therefore, thins down rapidly and the calf fattens equally quickly.

The growth rate of grey seal calves is astonishing from birth to a fortnight old, by which time they are tight with fat. This photograph of a calf suckling shows the relative bulk of mother and child. Maternal care is very much in evidence when the calf is young, but this attribute varies remarkably. Some calves are left utterly a fortnight after birth, some are suckled to three weeks of age, and rare individuals are cared for until they are a month old. The white coat begins to be shed at a fortnight, and when the calves are a month old they are clad in a short, blue sea coat of great beauty.

Imagine these small people, who have been so intensively fed since birth, now abandoned by their mothers! They may be at any height from thirty to three hundred feet above the sea. Their experience of getting about is negligible, yet they now face the perilous journey to the sea on their own initiative and they must of necessity starve until they get there. It is inevitable that tragedies should occur, not

"I took the camera from my eye and sat up to show him I was a man. He seemed positively grieved at the deception..."

A three weeks' old grey seal changing coat

from falling sheer into the sea, for water is kind to a seal, but from dropping on to rocks which are just or not quite covered. Some of the babies may get down in a week, others take a month to do so, in which case they have lost much of their accumulated fat.

Bulls and cows leave the breeding ground in November and they go to the skerries where they rested after their inward migration to Rona. One of these skerries, Loba Sgeir, is ringed by a violent surf and it is the place where the maiden cows breed. Curiously enough, although I saw matings occurring there, it did not seem that the bulls observed territorial spacing in the same way as on the calving grounds. Most of the bulls, also, were young ones. This is a state comparable with that found in some primitive human societies.

When Loba Sgeir receives the spent adult stock after the breeding season, it presents a very different appearance from the noisy gathering of September. The animals lie quiet, very often scratching themselves. They are staying on the skerry until their old coat is rubbed and scratched out. Then they go to sea again and do not return to Rona until the next breeding season. We see, therefore, that this surf-ringed skerry serves as a sanctuary for them, saving the maiden cows coming on to the calving grounds and allowing the adult stock to leave the main mass of the island as soon as reproduction is accomplished.

Long Before Darwin

Linné's Views on the Origin of Species

By Gabrielle Rabel

"*By this hypothesis, every sagacious botanist is admonished that from now on he should very carefully study the origin of species and undertake experiments as to whether they cannot be produced by art or by chance.*" *Linné*, Fundamentum fructificationis, 1762.

The above instruction will baffle many a reader who has been taught the current story that Linné believed obstinately and fanatically, on the grounds of an orthodox religious creed, in the "dogma of the constancy of the species", and that no idea ever passed through his brain that existing species might have evolved from others, or be changed into others.

I am afraid that some of those who speak glibly about the "dogma of the constancy of the species" would be very embarrassed, if some modern Socrates was going to cross-examine them in order to find out what exactly they meant by this term. For whoever wants to discuss the constancy or inconstancy of the species should be able to explain what a species is, and I have not yet met anyone who could do this. Can we investigate whether something is constant, if we do not know what we mean by this something?

To Linné, when he started his career, the problem seemed comparatively simple. For indeed he began by thinking that God had created every single species "with his own hands". And in one of his first publications, *Fundamenta Botanica*, a slender booklet, which appeared in 1731, containing 356 aphorisms without any explanation, aphorism 157 reads: "Species tot numeramus quot diversae formae in principio sunt creatae" (We number as many species as there were separate forms created in the beginning). 158 reads: "Varietates tot sunt quot differentae plantae ex eiusdem speciei semine sunt productae" (Varieties are as many as are produced as different plants from seed of the same species). Mark that this is the only definition of species and varieties which Linné gives and can give. God has created the species distinct from each other, but, as we read at various other places, Nature, in a sporting mood, just playing, has formed scores of varieties from their seeds. In Classes Plantarum 5, the definition of the species is repeated in more words: "There are as many species as the Infinite Being created different and *constant* forms upon this globe. These, according to the laws of generation, produce others similar to themselves, but more numerous than at first existed. Consequently, there are as many species as there are divers forms or structures to-day, rejecting those which the locality or some chance has caused to be slightly different (varieties)."

If the species are supposed to have remained constant from the day of Creation to the present day, it means that only constant characters *can* be considered as characters of the species, and characters which do *not* appear to be constant must be termed varieties. This distinction indeed is nothing more, and nothing less, than a *definition of the species*.

When Linné says: "The names of the species should be taken from those parts of the plant which are not variable", we feel that this is a clean and simple definition. Species characters are those which are "certain, distinct, fixed and constant". Ray had, before Linné, cautioned against the

habit of multiplying the names of species, indicating that certain features are induced by soil and climate and that "plants left in the same soil and neglected revert to the form and appearance they had in the woods". Linné who, even as a boy, had started transplantation experiments in his father's garden, soon developed the doctrine that it was necessary to transfer every newly discovered plant into the botanical garden and to observe its further behaviour. Only after having found the new features to remain constant in culture, was he willing to concede such a plant a species name. He clad this rule in one of his fascinating epigrams: "Culture, the mother of varieties, is also the best examiner of varieties."

When Linné found plants looking as if they belonged to the same species and yet differing according to whether they lived in the mountains or in the valleys, in dry or humid soil, he argued that these differences were produced by the surroundings, and consequently all such forms were only varieties of one and the same species. This definition was clean and simple, but it could only be upheld together with the conviction that there really exist characters which cannot be changed by either outer or inner factors. As soon, however, as a scientist assumes that any feature whatsoever may mutate one fine day into another, he does not only lose the theory of the constancy of the species, but at the same time loses the definition of the species.

And this is what happened. If all characters are subject to change, what, then, is the fundamental difference between species and varieties? Every critical-minded biologist freely admits that it is absolutely arbitrary, a matter of individual taste and experience, which plants enjoy the honour of being grouped into different species (or even genera) and which can only boast the title of subspecies or varieties. Botanists and zoologists, if you ask them, will all tell you that there are genera which contain only two or three species according to one man, but perhaps a dozen or a hundred according to another.

Plants which agree in their "fructification" (that is, flower and fruit) were united by Linné into a genus. Within the genus, differences occur with regard to roots, stems, leaves, etc., but even among the fixed and constant characters of that type there were many which Linné thought too insignificant to be included into the description of the species. Therefore, he thundered against the "anthophili", amateurs, florists, gardeners who, each time they observed a new form in their gardens, hastened to create a new species and vest it with some pompous and sensational name, such as *Triumphus Florae*, *Corona Europae*, *Splendor Asiae*. He considered such trifling differences as being below the notice of the true botanist and cautioned his pupils against catching the infection of this idle amusement. In his *Critica Botanica* which fortunately has appeared in an excellent English translation (Sir Arthur Hort, 1938), Linné exclaimed: "And alas! what a mass of new species have even the most ingenious of recent botanists discovered! Bauhin, for example, has discovered 600, and Tournefort an infinite number...."

* * *

Nothing can show more clearly Linné's real meaning and intention than the following sentences: "The Almighty Founder of the Universe desisted from his work of Creation on the seventh day and there was no new creation every day, but there was a continued increase of the things already made. He created but One Man according to the Holy Scripture, whereas if the most insignificant characteristic sufficed to make a species, quite a thousand species of Man are extant to-day. For we have men with hair white or black or red or gray, men with faces white or red or brown or black, men with noses long or straight or hooked or snub or aquiline; we have giants and dwarfs, fat men, thin men, tall men, stooping men, gouty men, lame men, etc., etc. But what moderately sane person would call all these distinct species?... Wherefore

I declare that size, locality, season of flowering, colour, scent, taste, use, sex, monstrosity, hairiness, duration, number, do not constitute distinct species."

Diagnostics depending on personal estimation, such as "pleasant scent", he ridiculed particularly. "A scent which is disgusting to a boy is most pleasant to a hysterical woman. A peasant entering a drugstore turns faint with the scent of the perfumes, but recovers when a heap of cowdung is presented to his nostrils."

* * *

In *Philosophia Botanica* which appeared in 1751, Linné reproduced the same 356 aphorisms which formed the contents of *Fundamenta Botanica*, but now a commentary was added to each paragraph. The famous sentence "Species tot...sunt..." is still unchanged, and indeed remains unchanged throughout all the following editions, but the commentary presents some pros and contras.

The plant produces the seed, the seed, falling, continues the plant somewhere else, where it produces the same again, in the same way the tree produces the branch, the branch the bud, the bud the green leaf.

The eternal circle of plant generation tells against the possibility of new species. And yet—

"Dubium movere Marchant, *act. paris.* 1741, Ego in *Peloria*, 1744, *Oratio de Telluris Habitabilis Incremento*, 1743, Gmelinus, *Orat. inaug. de novorum vegetabilium post creationem exortu*, Tuebingen, 1749."

What about these "doubts"?

If we follow the hint "Ego in *Peloria*..." we find an account of highest interest, especially with regard to Linné's scientific temperament. This hint refers to a paper which appeared under the name of Daniel Rudberg in 1744. The dissertations, with which Linné's pupils obtained their master's or doctor's degree, were in fact—as is not quite unusual in our days—works of the teacher himself. He published them under the general title *Amoenitates Academicae*, that is, academic entertainments or divertissements. The papers were presented "sub Presidio Caroli Linnaei", the pupils acting as respondents. The style of these treatises is exceedingly queer, inasmuch as Linné is sometimes referred to as "our distinguished President", while, sandwiched between paragraphs which smack of the pupil, there are others in which the distinguished President himself seems to step down from the rostrum and to speak for himself in the first person.

A new Linné is revealed in these divertissements to those readers who only knew his classical works, his text-books characterized by the utmost word-thriftiness and an axiomatic, dry, deductive style. Unfortunately, and incredibly, these really entertaining miscellaneous tracts which form eight volumes have, for the greater part, not been translated into any modern language. Therefore, I shall reproduce Rudberg's dissertation rather fully. It is certainly of prime importance to be aware of the doubts which Linné felt as to the fact that all species remain for eternity as they were created in the beginning.

The preface begins with the statement that "in our country a vegetable was recently discovered, of such striking features that one could well doubt whether Nature has ever produced anything similar". Two pages continue in this almost boasting tone, a tone of amazement at a stupendous "metamorphosis of plants", a prodigy most worthy of the attention of the scholars.

The great prodigy was found in 1742 on a little island not far from Upsala by a student who lived in this neighbourhood and put it into his herbal. From there it wandered into the herbal of the "Sacrosanctae Theologiae Doctor ac Professor Primarius Domus Olaus Celsius". Detailed study was impossible owing to the dried and pasted condition of the plant. But when Celsius showed it to "Domino Presidi", Linné managed to open the flower and was stupefied to recognize it as a *Linaria* of a type never seen before, just as if it had come from the Cape of Good Hope or Japan.

"We call this plant *Peloria*", says Rudberg, "from its history and to make it an omen for our work." *Pelor* is Greek and means something strange and monstrous. One of the monstrous features of this *Linaria* was that it had a regular corolla, and it is interesting that to this day regular flowers occurring in a species normally irregular are called "peloric".

A fervent desire to see this prodigy living prompted Linné to hurry immediately to the student discoverer and with him to the place where he had found it growing among other *Linarias*. He brought it home into his garden. Rudberg says: "If we state that the *Peloria* has been produced by the *Linaria*, we would seem to assert something miraculous and incredible. It would indeed not be a greater miracle if a pear tree produced narcissus, a thistle bore figs or a thorn grapes. And yet there are so many reasons for assuming that this has actually happened that no one who compares the structures of *Peloria* and *Linaria* can deny it.... As to their outward appearance, they are so similar that one can hardly distinguish the two. But when we open the flowers, we are struck by differences such as never occur in varieties. In varieties, size and form of leaves, colour, number of petals and many other features may differ, but never, never does it happen, as in the case of the *Peloria*, that the fructification differs in varieties of one and the same species. And since in Linnaeus' system the organs of fructification constitute the criterion for distinguishing classes, *mother Linaria and daughter Peloria not only belong to different species or even genera, but to different classes*." *Linaria* would have belonged to "Didynamia Angiospermae" and *Peloria* to "Pentandria monogynia".

The author states that *Peloria* seems to multiply by its own seeds and never to revert to the *Linaria* from which it has arisen.

"It was the bliss of this century of ours to discover phenomena not only unknown to any previous age, but even incredible." Examples mentioned are the miracles of the bees which are conceived by their grandparents, of the polyps which regenerate when cut into pieces, contrary to all physico-mechanical laws, and of the corals, plants and animals transformed into stones.

"Wormsius in Museum 150 describes a spica which had hitherto been of rye and now become barley; Gerardus in *hist. pl.* 65 tells of a spica of wheat in which, around its central part, some grains of oat had been produced. From this Rajus (in his *Catalogue of Non-British Plants*) inferred that metamorphosis is possible though only among species closely related to each other. More recent authors rejected such notions as being contrary to the nature of generation, for all that is born is similar to its parents, and we refuse to believe that the peaceful dove could give birth to ferocious eagles. While we relinquished the opinion of the older writers concerning rye, barley and oats, we do assert that the metamorphosis which changed a *Linaria* into a *Peloria* is even greater....

"The cause of this mutation is so far hidden to us. When such a thing happens in the animal kingdom, it should be ascribed to an unnatural sex instinct coupling different species, from which a mixture arises, as for example the mule. But such hybrids are not propagated, as Nature forbids that more quadruped species should exist than there were in the beginning of things.... As to the vegetable kingdom, it is certain that many forms were mixed, of which few, if any, show traces of former times. And we cannot assert that the *Peloria* owes its existence to a cause other than foreign impregnation, though which flower, by its impregnation, induced a *Linaria* to produce a *Peloria* we cannot imagine. This will have to be studied in the field."

Rudberg here quotes Marchant's paper in *Act. Paris.*, the gist of which is that this botanist believed to have discovered a new *Mercurialis* species in his garden, which, however, Dominus Preses immediately recognized as a variety. Linné's own *Oratio de Telluris Habitabilis Incremento* expounds that, according to geographical and geological observations made by Linné,

the terra firma is steadily increasing, that originally the portion of the earth raised above the waters was very small and on this very small area only one hermaphrodite and one couple of bisexual creatures had been living. Linné demonstrates with many examples and figures how enormous are the possibilities for the multiplication of organisms and the distribution of seeds all over the world. These observations work both ways—towards the future, showing how "the many come from the few"—and towards the past, indicating that one couple was indeed enough to start all the wealth of organisms existing at present.

* * *

The fourth treatise mentioned as raising doubts as to the age of the species, Gmelin's *Sermo academicus de novorum vegetabilium post creationem exortu* is not at my disposal, but according to a report given by Moebius (*Ostwald's Klassiker*, 105) Gmelin in his famous inaugural speech discussed the *Peloria* as well as other similar newcomers observed by himself, and came to the conclusion that the matter was not yet settled.

The *Peloria* divertissement concludes, as follows: "If further observation shows that the *Peloria* does not revert to the ancestral *Linaria* form, but remains constant, the miraculous thesis can be established that actually new species are formed in the vegetable kingdom, and that one and the same genus can develop different organs of fructification. *And thereby the foundation of the entire science of Botany would collapse and the natural classes of plants would be destroyed.* Up to that time, however, all experts may duly admire a stupendous child of Nature in our *Peloria*."

Is that the attitude of a dogmatist? Is it probable that a man who has the least tendency to dogmatism could feel such a deep and enthusiastic satisfaction in the face of a discovery which is liable to overthrow the entire foundation of science—a foundation which he himself has laid and which has made him famous? I suggest a dogmatist would rather have concealed this discovery as long as possible, thinking: "Si les faits ne sont pas d'accord avec la théorie, tant pis pour eux." At least, he would have waited, until time and experiment would have confirmed this inconvenient miracle beyond any doubt. But the *Peloria* had been discovered in 1742, and in 1744 the paper was published, fresh from the oven, in glowing joy. It displays the candid openheartedness of the true scientist who is always ready to submit to facts and to admire Nature even at the expense of his own favourite doctrines. On another occasion Linné said: "We can learn the divine laws as embodied in Nature, much more readily from experience than from preconceived opinions."

Later it was found that the *Peloria* was not propagated by seeds. It was, then, called a monstrosity and we do not find it in any of Linné's lists of plants.

In *Philosophia Botanica*, par. 317, Linné says that the tendency to overestimate the varieties even goes so far to support the view that varieties could develop into species and species into genera. "This heresy was opposed first by Vaillant, then by myself, then by Jussieu, Haller, Royen, Gronovius and quite a few others, to prevent science from crashing into pieces."

That so many authorities were necessary to suppress this view in the eighteenth century is certainly a surprising bit of information.

* * *

We have no evidence that Linné ever changed his attitude to this "heresy". However, he changed his view thoroughly upon the dictum that no new species had been or were created after the seventh day of Creation.

Already in the *Peloria* article we found him considering the possibility that the crossing of different species might produce new ones. In 1756 he for the first time deliberately performed such a crossing and obtained a fertile hybrid. His treatise on

Plantae Hybridae contains a long list of plants which he thought might owe their existence to bastardization. And when in 1760 the Petersburg Academy of Science proposed a prize for the best paper "to prove or disprove with new arguments the doctrine of the Sex of Plants", Linné sent in a paper on this subject and won the prize. The definitely new argument which settled the question was the possibility of artificial fecundation with all its logical consequences.

Almquist tells us that Koelreuther, the German botanist, happened to live in Petersburg at that time and that his voice contributed to the awarding of the prize to Linné. This is interesting if we consider the fact that in later years Koelreuther was generally considered the first to produce hybrids by experiments.

As to the theory of sex in plants, Linné himself says in his treatise: "The ancients who grew dates and figs must have known that it was necessary to place male flowers over female ones in order to make them fertile....The English ascribe the discovery to Sir Thomas Millington, Savillan Professor (of Geometry) in Oxford. Dr Nehemiah Grew tells us in his *Anatomy of Plants* that in a conversation Millington suggested that the stamina might be analogous to the male genital organ."

Millington, however, did not publish his ideas and Linné knew and said so elsewhere (*Sponsalia Plantarum*) that the first scientific publication concerning the subject was Camerarius' *De Sexu Plantarum Epistola* written in Tuebingen in 1694. At all events, the problem proposed by the Petersburg Academy, viz. "to prove or disprove the Sex of Plants", teaches us that, as late as 1760, it was not yet a generally acknowledged fact that plants like animals are divided into males and females and that an act of fecundation is necessary to produce offspring. Still less did any botanist know of what this act exactly consisted. But, although it seems that the definite proof, valid even in Russia, was only given by the paper of 1760, in fact the very first publications of Linné had already made the sexuality of plants known in wide circles, and so this discovery was attached to his name, just as the theory of evolution was connected with the name of Darwin, though it had been in existence a good long time before him. This condition we must bear in mind to understand the enormous popularity which Linné enjoyed.

To the present generation, his "Sexual System" seems to be the driest of all dry subjects. It is hard for us to reconstruct the enormous impression which the system made at that time. Linné tells us that as a young boy he had read a book by Vaillant, *De Sexu Plantarum*. Immediately he set himself to the task of examining every plant he could get hold of, with regard to its stamina and pistils, and he grew excited when he noticed to his great surprise that these parts were constant in every species. That was a fact of enormous importance which could no longer be neglected by the botanists. In his autobiography, a rather unusual human document, Linné comments: "That plants have sex, was sometimes asserted and sometimes denied. But he proved its existence so clearly that all opponents were silenced. And who could better do this than Linné? For he had examined all known plants, an undertaking which claimed the entire time of a man. And he even went the length of basing on these most essential parts of vegetables the whole of his *Methodus plantarum* or his Sexual System."

(*The conclusion of Dr Rabel's article will be published in the April number of* Discovery)

The Fringe of the Sun

Nebulium and Coronium

By C. G. JAMES

ON the clear serene night of 20 August 1864, Sir William Huggins was working in his observatory at Tulse Hill. His 8-in. refracting telescope had been fitted with the Royal Society's new spectroscope, an improved instrument which Huggins himself had perfected for astrophysical research. The telescope was first directed at the planetary nebula in Draco and afterwards at the great nebula in Orion, and Huggins saw with keen satisfaction, and no little excitement, that the light from these nebulae was split into a bright line emission spectrum, very faint but shown unmistakably by the precise spectroscope he was using.

This, indeed, was a great discovery, for as Huggins said, "These nebulae are shown by the prism to be enormous gaseous systems"—a point which had often been debated. For though, before Huggins, the speculative Laplace and the more prudent and practical observer Herschel had expressed the same opinion, there were many astronomers who thought that, given a large enough increase in telescopic power, all of the nebulae would eventually be shown as star conglomerates, even as at that time the giant reflector of the Earl of Rosse had exhibited one or two of the nebulae thus partially resolved.

In all, Huggins investigated seventy nebulae spectroscopically, and he showed that one-third of these were gaseous. The rest, possessing as they did continuous or absorption spectra, were found to be either star clusters or consisting partly of stars in different stages of evolution or decay. But of the Orion nebula, about which there had been much discussion, Huggins wrote, "The light from the brightest part of the nebula near the trapezium was resolved by the prisms into three bright lines in all respects similar to those of the gaseous nebulae."

Some of the spectra lines of the whole of the Orion nebula showed that hydrogen was present, while further enquiry identified lines characteristic of various other known elements. But there were two lines noted in the green that evaded identification and the elusive matter that emitted light of those particular wave-lengths resisted all attempts made by astrophysicists to pin a label to it. These unidentified lines were later found in the spectra of many of the gaseous nebulae and, with improved instrumental power coupled with photography, similar unidentified lines were also found and ascribed to the same mystery element. The strong pair of lines in the green portion of the spectrum have been designated N_1 and N_2, their wave-lengths being λ 4959 and λ 5007. There is another line λ 4363; still yet another close pair occurs in the ultra-violet end of the spectrum.

The nineteenth-century astronomers originally assumed that these lines were the hall-mark of an element which had not then been discovered terrestrially. In fact it was given the atomic weight "three" in the scale of the elements, and was named NEBULIUM—the gas of the nebulae. As one writer put it, "The recognition mark of nebulium is a vivid green ray by the emission of which it is known to have a concrete existence."

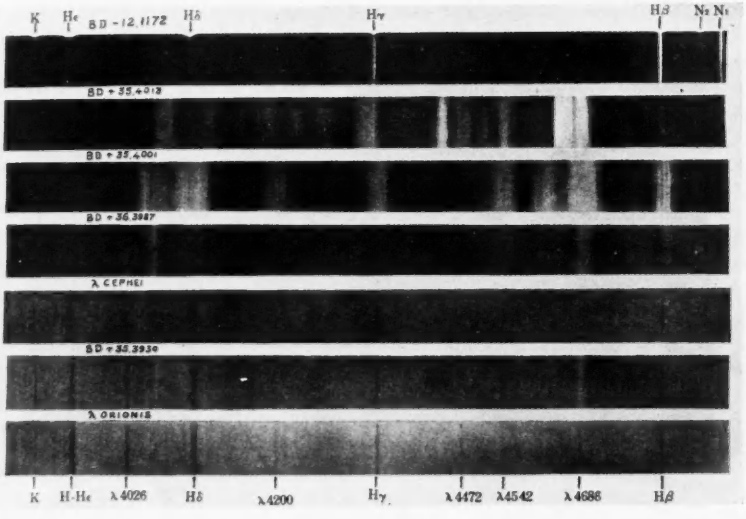
Afterwards the question arose as to whether this green shining gas, this "element" that had cropped up so un-

expectedly in outer space, was really something that had evaded chemical discovery on earth. Was it something more primitive? It must be confessed that, in many cases, speculation overrode sound scientific method, and it was suggested in several quarters, and by good authorities, that this celestial radiance might be due to the primeval protyle or "world-stuff", the cosmic protoplasmic fluid from which the universe had been manufactured in the beginning. Indeed, Professor Stokes went so far as to state, "It may possibly indicate some form of matter more elementary than we know on earth...."

However, the investigation of nebulium continued, and as new elements were discovered, so were their emission spectra lines matched with those of nebulium. But to no purpose. None were found to coincide. The gaps in the table of elements became fewer and fewer; hope began to fade. It gradually came to be accepted that the hypothetical nebulium was some familiar gas clothed in an unfamiliar fashion.

And so it proved. This assumption was made, and the problem strongly attacked by Dr Wright at the Lick Observatory. The assault was continued by I. S. Bowen, and nebulium began to shed its cloak of mystery. Bowen, in 1927, showed by the use of modern atomic theory, and by elegant mathematical reasoning, that firstly the lines of nebulium were of the variety that require a huge amount of energy for their excitation. Secondly, the gas must be in a high state of tenuity—so diffuse, in fact, as to be millions of times more rare than any gas we can possibly obtain by experimental physical means.

It was shown that the probable source of energy which excited these tenuous condensations to emit the unknown spectra lines was possibly the intensely hot stars which, according to the Harvard (Draper) stellar classification, are known as the Type "O" (Wolf-Rayet) stars, or the Type "B" (Orion or helium) stars, the temperatures of which may be anything between 35,000 and 100,000° C.

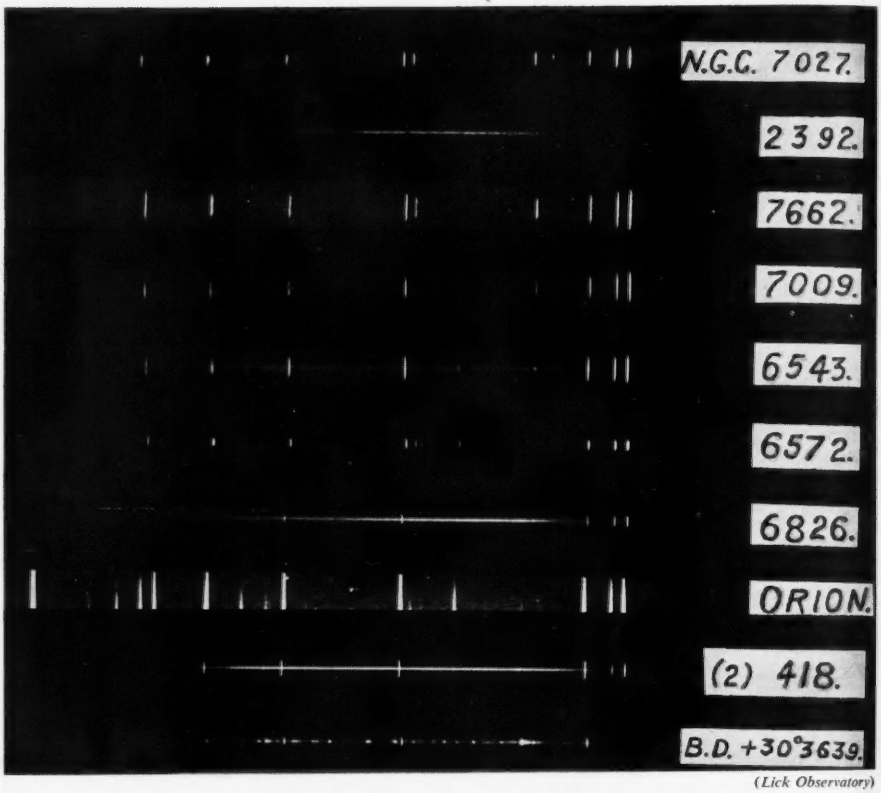


Some Typical Stella Spectra (Curtiss): Nebula-Class Pa, Stella-Class O. Note N_2 and N_1 lines

(*Mount Wilson Observatory*)

The Great Nebula in Orion. (*M* 42, *N.G.C.* 1976.) *Exp.* 3 *hrs.*
19 *Nov.* 1920. 100-*inch Reflector*

These high-temperature stars are found in close proximity to the nebulae that exhibit nebulium lines; the Type "O" sometimes forms the nucleus of the planetary nebulae, while the Type "B" is generally connected with the irregular nebulae "without form or void" similar to Orion.

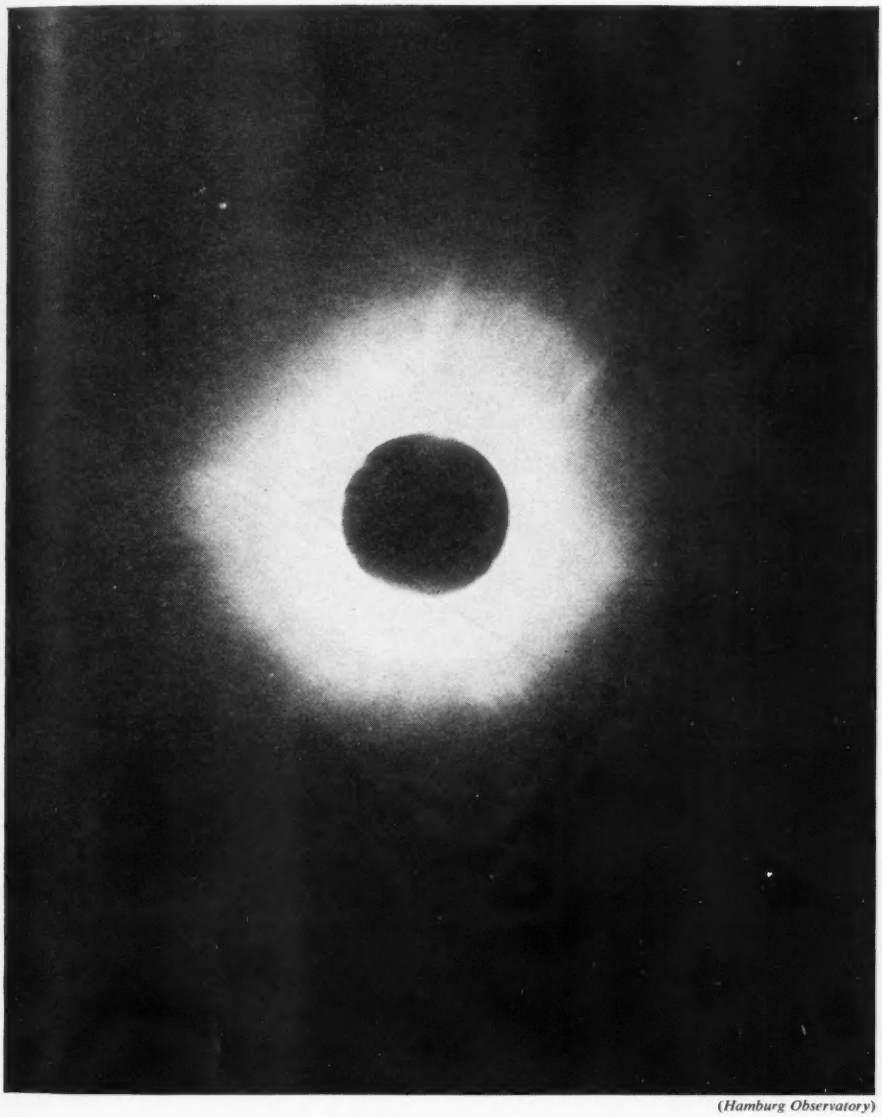


(*Lick Observatory*)

Spectra of Nebulae. 36-*inch Reflector*

The emission of a certain variety of intense energy from these stars, combined with the wide spacing of the atoms in a nebula, is the cause of the characteristic nebular lines, for the conditions postulated thus allow of relatively forbidden transitions of the satellite electrons of the nebular atoms. As is well known, the atom may be pictured as consisting of a nucleus of positive electrical charge, while to balance the system there are satellite electrons which are charged negatively, the electrons rotating in certain possible orbits round the nucleus. The transition of an electron from one orbit to another is possible. Some transitions, however, are forbidden in the normal state of the atom and are only possible under very special and stringent conditions. This is termed a *relatively forbidden* transition. When an electron makes a forbidden move due, maybe, to the bombardment of the atomic system by a high-speed particle, or radiation from an outside source, it may also radiate energy in the form of light of a certain quality or wave-length.

The evidence produced by Bowen indicates then that the N_1 and N_2 lines are due to out-of-the-ordinary electronic movements in a gaseous atom, the gas being *doubly ionized oxygen*, that is, oxygen that has lost two electrons from its normal



(*Hamburg Observatory*)

Solar Corona. 29 *June* 1927. *Jokmokk*

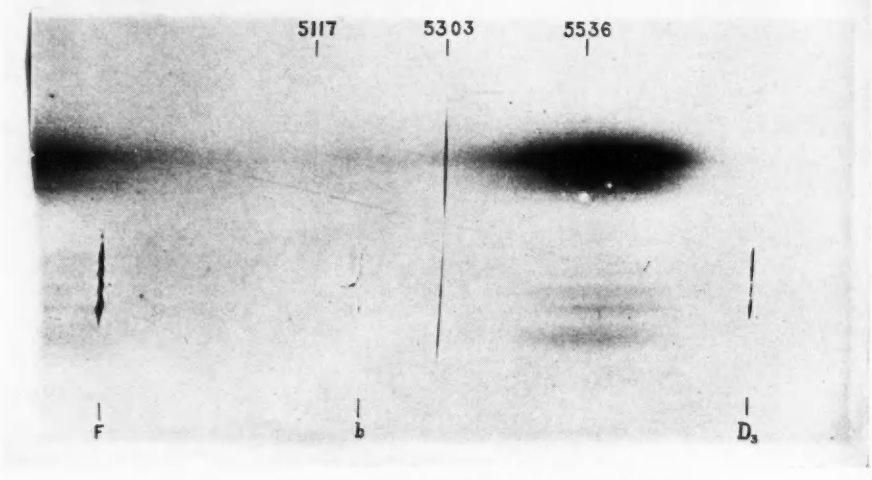
complement of six. The λ 4363 line is also probably due to oxygen in the same state, while the lines in the ultra-violet may emanate from singly ionized oxygen. Still other lines may be attributed to ionized nitrogen. These elements which produce the "nebulium" spectra are the main constituents of our earthly atmosphere, and

as Sir Arthur Eddington has so delightfully put it, "The light that never was on land or sea is just common air." Truly, as another writer has said, nebulium itself has vanished into thin air...!

The mighty nebulae are very remote from the tiny planet, Earth. But near our home mystery still prevails. Our own star, the sun, has its puzzling constituent. Sir Robert Ball, in 1893 (when he was Royal Astronomer of Ireland), said that we have good reason to think that there are two other elements at least in the sun which are foreign to our terrestrial chemistry. At that time these elements received the provisional names of coronium and helium.

is very prominent, whilst at other periods it is weak. It would appear from observations and photographs taken during totality that its general size changes in accordance with the number of sun spots or eruptions that appear on the solar disc. These, as is well known, vary in average number over a cycle of approximately eleven years.

Some observers have noted that the corona form is constantly changing even during the short period of totality, but as a general rule it may be said that when there are the least number of spots on the sun the corona is at its largest. During this period of minimum sun-spot activity long streamers, or wings, of the corona



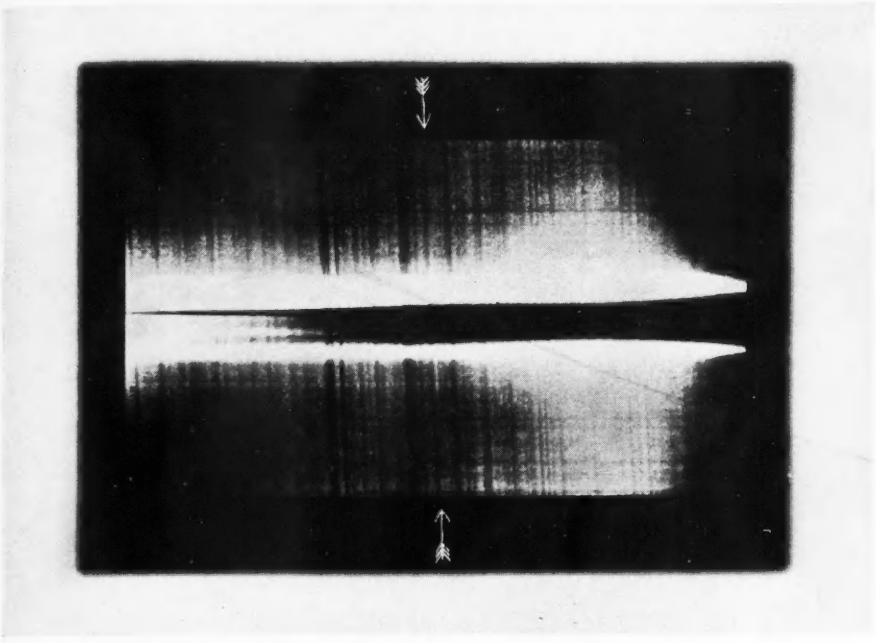
Spectrum of Corona. 30 *Aug.* 1905. (*Dyson.*) *Sfax, Tunis*

Helium is now a well-known gas. But coronium, the hypothetical element which is a constituent of the solar corona, has not, as yet, definitely yielded up its secret, although there are indications that, like nebulium, it is a well-known gas, or gases, acting in a strange way.

The solar corona is only observed during a total eclipse of the sun. It is an irregular halo of exquisite and delicate pearl-coloured light arrayed round the eclipsed solar disc. Its form varies. Sometimes it stretch from the solar equator with lesser streamers or tufts at the poles of the sun.

This winged shape has given rise to an ingenious theory (suggested first by E. W. Maunder) that the symbol of Ra, the sun god, a deity of the ancient Egyptians, is an attempt to delineate the shape of the corona. If such is the case these ancients must have been keen observers of eclipse phenomena.

According to various modern authorities who base their theories on spectroscopic



Coronal Line 5303 (*without eclipse*). *Exp.* 6 *min.* 10 *Aug.* 1930. (*Lyot.*) *Pic du Midi*

observations, the corona consists mostly of gaseous matter with a sprinkling of meteoric or cosmic dust, shining partly by reflected light from the photosphere, and partly by its own intrinsic light.

Spectroscopic observations on the corona are, like those of the nebulae, full of interest. The main characteristic of the spectrum is a very strong line in the green (wave-length λ 5303), whilst other emission lines, some very faint, can also be seen. These lines are superposed upon a relatively weak continuous spectrum which can probably be attributed to the reflected or scattered light from the minute particles near the sun.

Now the line λ 5303 does not coincide with that of any of the known elements. There has been a suggestion in some quarters, however, that it may match one of the lines of the aurora borealis. Thus it may well be that there is some connexion between the aurora and the corona, for both vary with sun-spot activity.

Another prominent corona line in the red has lately been studied closely. It was first discovered during the eclipse of 1914, but it would appear from later observations that it changes its intensity in a marked degree. Most of the corona lines vary somewhat in strength at various periods, as the testimonies of eclipse expeditions indicate. This is what might be expected, for we have already noted how the corona itself changes at sun-spot minima and maxima. But the change in the red-line intensity would seem to be greater than the rest. A suggestion has been made that the origin of this line is hydrogen.

Sir Norman Lockyer's statement that coronium was possibly an element lighter than hydrogen cannot be entertained in any circumstances in the face of modern atomic theory. It is impossible for an

element to exist that is lighter than the first element in the atomic scale, although the discovery of helium in the sun (the next lightest element to hydrogen) before it was discovered terrestrially must be attributed to Lockyer.

However, to review the most recent research work, it is possible that coronium may be diffuse oxygen in an unfamiliar ionized state, although this cannot yet be stated with certainty. If such proves to be the case coronium, like nebulium, will have lost its status as an element of mystery, and the solution of the problem will have gone a long way to suggest that there is nothing new under the canopy of heaven —only change. This postulate is a far-reaching one. Discovery of the future will probably be directed more and more to the proof of this statement.

Mr Tompkins in Wonderland

By Professor G. GAMOW

Dream IV: More Uncertainty

ONE grey November morning Mr Tompkins was dozing in bed, when he became aware of somebody's presence in the room. Looking round, he discovered that his old friend the Professor was sitting in the arm-chair, absorbed in the study of a map spread on his knee.

"Are you coming along?" asked the Professor, lifting his head.

"Coming where?" said Mr Tompkins, still wondering how the Professor had got into his room.

"To see the elephants, of course, and the rest of the animals of the quantum jungle. The owner of the billiard room we visited recently told me his secret about the place where the ivory for his billiard-balls came from. You see this region which I've marked with red pencil on the map? It seems that everything within it is subject to quantum laws with a very large quantum constant. The natives think that all this part of the country is populated by devils, and I am afraid it will hardly be possible for us to find a guide. But if you want to come along, you had better hurry up. The boat is sailing in an hour's time and we still have to pick up Sir Richard on our way."

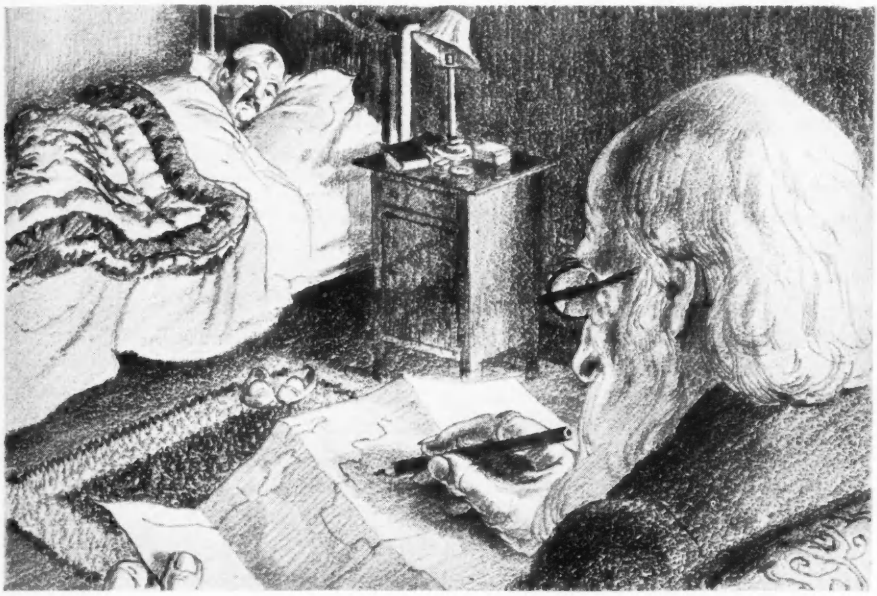
"Who is Sir Richard?" asked Mr Tompkins.

"Haven't you ever heard about him?" The Professor was evidently surprised. "He is a famous tiger-hunter, and decided to go with us, when I promised him some interesting shooting."

They came to the docks just in time to see the loading of a number of long boxes containing Sir Richard's rifles and the special bullets made from lead which the Professor had obtained from the lead mines near the quantum jungle. While Mr Tompkins was arranging his baggage in the cabin, the steady vibrations of the

boat told him that they were off. The sea journey was nothing remarkable, and Mr Tompkins scarcely noticed the time until they came ashore in a fascinating oriental city, the nearest populated place to the mysterious quantum regions.

"Now", said the Professor, "we have to buy an elephant for our journey inland.



"Coming where?" said Mr Tompkins, still wondering how the Professor had got into his room

As I do not think any of the natives will agree to go with us, we shall have to drive the elephant ourselves, and you, my dear Tompkins, will have to learn the job. I shall be too busy with my scientific observations and Sir Richard will have to handle the firearms."

Mr Tompkins was rather unhappy when, coming to the elephant market on the outskirts of the city, he saw the huge animals, one of which he would have to handle. Sir Richard, who knew a lot about elephants, picked out a nice big animal and asked the owner what price it was.

"Hrup hanweck 'o hobot hum. Hagori ho, haraham oh Hohohohi", said the native, showing his shining teeth.

"He wants quite a lot of money for it," translated Sir Richard, "but says that this is an elephant from the quantum jungle and it is therefore more expensive. Shall we take it?"

"By all means," explained the Professor, "I heard on the boat that sometimes elephants come from the quantum lands and are caught by the natives. They are

much better than the elephants from other regions, and in our case we shall have quite an advantage because this animal will feel at home in the jungle."

Mr Tompkins inspected the elephant from all sides; it was a very beautiful, large animal, but there was no marked difference in its behaviour from the elephants he had seen in the Zoo. He turned to the Professor—"You said that this was a quantum elephant, but it looks just like an ordinary elephant to me, and does not behave in a funny way, like the billiard-balls made from the tusks of some of its relatives. Why doesn't it spread out in all directions?"

"You show a peculiar slowness of comprehension", said the Professor. "It is because of its very large mass. I told you some time ago that all the uncertainty in position and velocity depends on the mass; the larger the mass, the smaller the uncertainty. That is why the quantum laws have not been observed in the ordinary world even for such light bodies as particles of dust, but become quite important for electrons, which are billions of billions of times lighter. Now, in the quantum jungle, the quantum constant is rather large, but still not large enough to produce striking effects in the behaviour of such a heavy animal as an elephant. The uncertainty of the position of a quantum elephant can be noticed only by close inspection of its contours. You may have noticed that the surface of its skin is not quite definite and seems to be covered with some fuzz. In course of time this uncertainty increases very slowly, and I think this is the origin of the native legend that very old elephants from the quantum jungle possess long fur. But I expect that all smaller animals will show very remarkable quantum effects."

"Isn't it nice", thought Mr Tompkins, "that we are not doing this expedition on horseback. If that were the case, I should probably never know whether my horse was between my knees or in the next valley."

After the Professor and Sir Richard with his rifles had climbed into the basket fastened on to the elephant's back, and Mr Tompkins, in his new capacity of mahout, had taken his position on the elephant's neck, clutching the goad in one hand, they started towards the mysterious jungle.

The people in the city told them that it would take about an hour to get there, and Mr Tompkins, trying to keep his balance between the elephant's ears, decided to make use of the time by learning more about quantum phenomena from the Professor.

"Can you tell me, please," he asked, turning to the Professor, "*why* do bodies with small mass behave so peculiarly, and what is the common-sense meaning of this quantum constant that you are always talking about?"

"Oh, it is not so difficult to understand", said the Professor. "The funny behaviour of all objects you observe in the quantum world is just due to the fact that you are looking at them."

"Are they so shy?" smiled Mr Tompkins.

"'Shy' is an unsuitable word", said the Professor bleakly. "The point is, however, that in making any observation of the motion you will necessarily disturb this

motion. In fact, if you learn something about the motion of a body, this means that the moving body delivered some action on your senses or the apparatus you are using. Owing to the equality of action and reaction we must conclude that your measuring apparatus also acted on the body and, so to speak, 'spoiled' its motion, introducing an uncertainty in its position and velocity."

"Well", said Mr Tompkins, "if I had touched that ball in the billiard room with my finger I should certainly have disturbed its motion. But I was just looking at it; does that disturb it?"

"Of course it does. You cannot see the ball in darkness, but if you put on the light, the light-rays reflected from the ball and making it visible will act on the ball —light-pressure we call it—and 'spoil' its motion."

"But suppose I used very fine and sensitive instruments, can't I make the action of my instruments on the moving body so small as to be negligible?"

"That is just what we thought in classical physics, before the *quantum of action* was discovered. At the beginning of this century it became clear that the *action* on any object cannot be brought below a certain limit which is called the quantum constant and usually denoted by the symbol '*h*'. In the ordinary world the quantum of action is very small; in customary units it is expressed by a number with twenty-seven zeros after the decimal point, and is of importance only for such light particles as electrons which, owing to their very small mass, will be influenced by very small actions. In the quantum jungle we are now approaching, the quantum of action is very big. This is a rough world where no gentle action is possible. If a person in such a world tried to pet a kitten, it would either not feel anything at all, or its neck would be broken by the first quantum of caress."

"This is all very well," said Mr Tompkins thoughtfully, "but when nobody is looking, do the bodies behave properly, I mean, in the way we are accustomed to think?"

"When nobody is looking," said the Professor, "nobody can know how they do behave, and thus your question has no physical sense."

"Well, well," exclaimed Mr Tompkins, "it certainly looks like philosophy to me!"

"You can call it philosophy if you like"—the Professor was evidently offended— "but as a matter of fact, this is the fundamental principle of modern physics—*never to speak about the things you cannot know*. All modern physical theory is based on this principle, whereas the philosophers usually overlook it. For example, the famous German philosopher Kant spent quite a lot of time reflecting about the properties of bodies not as they 'appear to us', but as they 'are in themselves'. For the modern physicist only the so-called 'observables' (i.e. principally, observable properties) have any significance, and all modern physics is based on their mutual relation. The things which cannot be observed are good only for idle thinking—you have no restrictions in inventing them, and no possibility of checking their existence, or of making any use of them. I should say...."

A large pack of tigers was attacking their elephant, jumping simultaneously from all sides

all sides

At this moment a terrible roar filled the air and their elephant jerked so strongly that Mr Tompkins almost fell off. A large pack of tigers was attacking their elephant, jumping simultaneously from all sides. Sir Richard grabbed his rifle and pulled the trigger, aiming right between the eyes of the tiger nearest to him. The next moment Mr Tompkins heard him mutter a strong expression common among hunters; he shot right through the tiger's head without causing any damage to the animal.

"Shoot more!" shouted the Professor. "Scatter your fire all round and don't mind about precise aiming! There is only one tiger, but it is spread around our elephant and our only hope is to raise the Hamiltonian."

The Professor grabbed another rifle and the cannonade of shooting became mixed up with the roar of the quantum tiger. An eternity passed, so it seemed to Mr Tompkins, before all was over. One of the bullets "hit the spot" and, to his great surprise, the tiger, which became suddenly one, was vigorously hurled away, its dead body describing an arc in the air, and landing somewhere behind the distant palm grove.

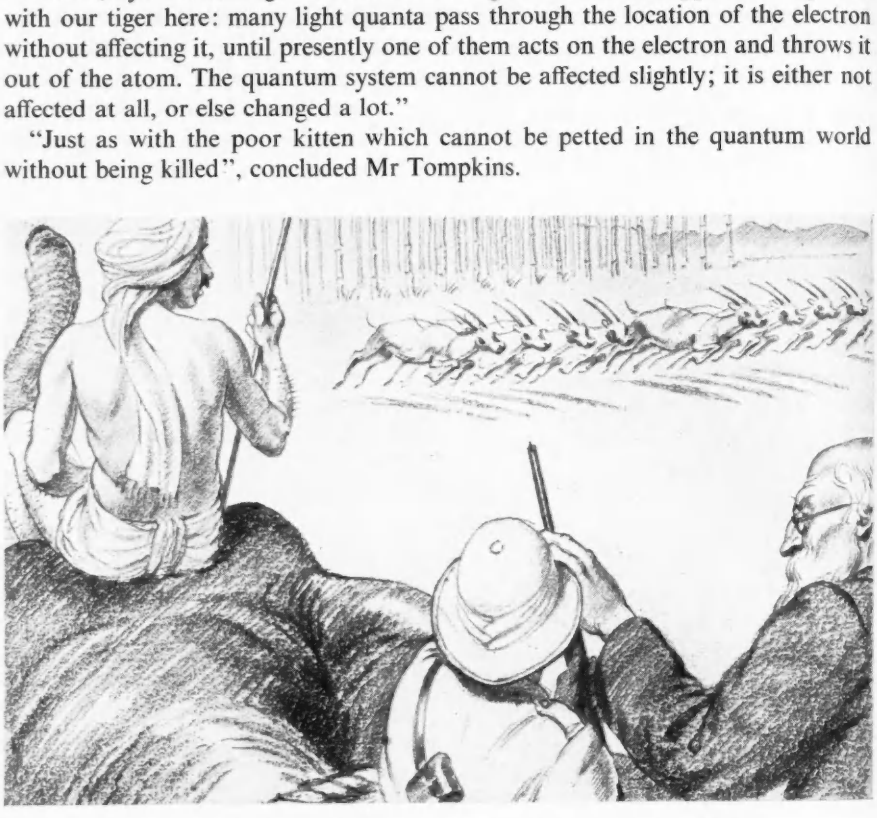
"Who is this Hamiltonian?" asked Mr Tompkins after things had quietened down. "Is he some famous hunter you wanted to raise from the grave to help us?"

"Oh!" said the Professor, "I am so sorry. In the excitement of battle I started to use scientific language—which you cannot understand. Hamiltonian is a mathematical expression describing the quantum interaction between two bodies. It is named after an Irish mathematician, Hamilton, who first used this mathematical form. I just wanted to say that by shooting more quantum bullets we increase the probability of the interaction between the bullet and the body of the tiger. In the quantum world, you see, one cannot aim precisely and be sure of a hit. Owing to the spreading out of the bullet, and of the aim itself, there is always only a finite chance of hitting, never a certainty. In our case we fired at least thirty bullets before we actually hit the tiger; and then the action of the bullet on the tiger was so strong that it hurled its body far away. The same things are happening in our world at home but on a much smaller scale. As I have already mentioned, in the ordinary world one has to investigate the behaviour of such small particles as electrons in order to notice anything. You might have heard that each atom consists of a comparatively heavy nucleus and a number of electrons rotating round it. One used to think, at first, that the motion of electrons round the nucleus is quite analogous to the motion of planets round the sun, but deeper analysis has shown that ordinary notions concerning the motion are too rough for such a miniature system as that of the atom. The actions which play an important role inside an atom are of the same order of magnitude as the elementary quantum of action and thus the whole picture is largely spread out. The motion of the electron round the atomic nucleus is in many respects analogous to the motion of our tiger, which seemed to be all round the elephant."

"And does somebody shoot at the electron as we did the tiger?" asked Mr Tompkins.

"Oh yes, of course, the nucleus itself sometimes emits very energetic light quanta or elementary action units of light. You can also shoot at the electron from outside the atom, by illuminating it with a beam of light. And it all happens there just as with our tiger here: many light quanta pass through the location of the electron without affecting it, until presently one of them acts on the electron and throws it out of the atom. The quantum system cannot be affected slightly; it is either not affected at all, or else changed a lot."

"Just as with the poor kitten which cannot be petted in the quantum world without being killed", concluded Mr Tompkins.



Sir Richard was ready to shoot, when the Professor stopped him

"Look! gazelles, and lots of them!" exclaimed Sir Richard, raising his rifle. In fact a big herd of gazelles was emerging from the bamboo grove.

"Trained gazelles", thought Mr Tompkins. "They run in as regular formation as soldiers on parade. I wonder if this is also some quantum effect."

The group of gazelles which was approaching their elephant was moving rapidly and Sir Richard was ready to shoot, when the Professor stopped him.

"Do not waste your cartridges," he said, "there is very little chance of hitting an animal when it is moving in a diffraction pattern."

"What do you mean by '*an*' animal?" exclaimed Sir Richard. "There are at least several dozens of them!"

"Oh no! There is only one little gazelle which, because it is scared of something, is running through the bamboo grove. Now, the 'spread out' of all bodies possesses a property analogous to that of ordinary light; and, passing through a regular sequence of openings, for instance between the separate bamboo trunks in the grove, it shows the phenomena of diffraction about which you might have heard at school. We speak therefore about the wave character of matter."

But neither Sir Richard nor Mr Tompkins could think at all what this mysterious word "diffraction" might mean, and the conversation stopped at this point.

Passing farther through the quantum land our travellers met quite a lot of other interesting phenomena, such as quantum mosquitoes, which could scarcely be located at all, owing to their small mass, and some very amusing quantum monkeys. Now they were approaching something which looked very much like a native village.

"I did not know", said the Professor, "that there was a human population in these regions. Judging by the noise, I suppose they are having some sort of festival. Listen to this incessant noise of bells."

It was very difficult to distinguish the separate figures of natives who were evidently dancing a wild dance round the big fire. Brown hands with bells of all sizes were constantly rising from among the crowd. As they approached still closer, everything, including the huts and surrounding big trees, began to spread out, and the ringing of the bells became unbearable to Mr Tompkins's ears. He stretched his hand out, grabbed something, and then threw it away. The alarm clock hit the glass of water standing on his night-table and the cold stream of water brought him to his senses. He jumped up, and started to dress rapidly. In half an hour he must be at the bank.

Colour in Painting

By Mary Barne

III. Balance of Tone and Quality of Colour

George Moore, in his *Modern Painting*, writes: "It is interesting and instructive to notice how those who seek the colour without regard for the values inherent in the colouring matter never succeed in producing more than a certain shallow superficial brilliancy; the colour of such painters is never rich or profound." What are these "inherent values"?

From the violet end to the middle of the spectrum, there is an increase in luminosity, very rapid as blue yields to green, until full yellow is reached; here brightness attains its maximum; it decreases towards the long-wave end, slowly in the orange, fairly rapidly in the red.

So, for most observers, for different people's eyes vary slightly in this respect, the hues of medium tone are, in full daylight, those that I have numbered 1, 2, 5, 6, 7, 8 and 9 (in very low illumination, such as twilight, greenish-blue appears the brightest

hue), and, of course, the intermediate gradations between 1 and 2 and between 5 and 9.

(For clearness, I will refer again to the numbered scale of twelve hues or chromata which I described last month. They correspond, roughly, in the intervals between their wave-lengths to the twelve semitones of another arbitrary scale, the chromatic in modern European music. They are:

(1) Spectral red (a deep blood-red).
(2) Orange-red or scarlet.
(3) Yellow-orange.
(4) A "cool" yellow.
(5) Leaf or moss-green (a "warm" green).
(6) Jade (or bluish) green.
(7) Peacock-blue (a blue that is almost green).
(8) Cyan-blue (its paler tints are known as "sky-blue").
(9) Violet-blue or ultramarine.
(10) Violet.
(11) Purple.
(12) Purplish crimson or "magenta".

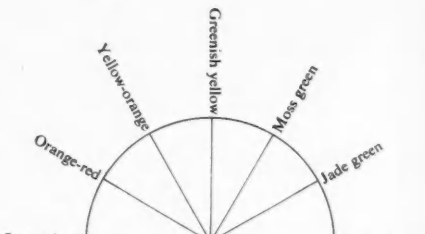
Their wave-lengths in Ångström units are: (1) 6900; (2) 6390; (3) 6130; (4) 5750; (5) 5520; (6) 5150; (7) 5000; (8) 4810; (9) 4420; (10) 4140; (11) and (12) are non-spectral hues.

I quote these twelve hues by the numbers I have given them.

Now arrange the twelve hues in a circle as at the top of this page.

Those that are opposite each other will be found to be complementaries, that is, combined in the proper proportion on a colour disc, or, in the form of lights thrown on a screen, they will produce white.)

The warmer reds, the greens, the blues—these may be called the normal or everyday chromata—are found all around us in nature and in the ancient works of man. Purple and violet, crimson and gold, are the regal hues, not for common use. Violet and the purples have the awe-inspiring, therefore depressing, qualities of kingship—yellow, its glory. Sunlight has a golden tinge; shadows go towards purple, except



on a dead white surface, such as snow; there they are ultramarine-blue and fairly luminous. Evening sunlight (because it has to pierce through a greater thickness of atmosphere, which allows only the long light-waves to pass) is more or less orange in hue. Thus yellow and orange-yellow, through association, have the cheering psychological effect of sunshine; a touch of either gives life and joy to a picture, but large spaces of these hues have an effect of glare and vulgarity. Violet, purple and magenta, on the other hand, make for morbidity and luridness; but, used in small quantities, help to "tone down" what might otherwise be a garish colour scheme.

Just as a drawing is "spotty", which is largely made up of dark tones, with some high lights scattered here and there and the half-tones left out, so would a picture be intolerable that had not a preponderance of the chromata of medium value.

If a soft golden glowing effect is desired (not one of brilliant mid-day sunlight which, as Constable and the Impressionists showed us, tends to desaturate and whiten all colours), the painter can—as in Delacroix's "Execution" picture that I have mentioned—make use of the hues on each side of yellow and orange in the spectrum (and, of course, in strict moderation, of these two hues themselves). And Rembrandt has shown how to give seriousness and weight

to a painting without the use of the non-spectral colours. But neither does he smother his work in the famous "brown sauce". His use of brown, and Chardin's, and, above all, Velazquez's, form a most interesting study. For brown, used carelessly, can have something of the vulgar quality of yellow (many browns are mixtures of black and yellow in various proportions). But Velazquez has the power of infusing browns (and greys), so dead in uninspired hands, with chromatic quality; he has translucent green-browns that make one think of sea-water in Atlantic caves; look at the background of "Lady with a Fan" in the Wallace Collection. Whistler has this secret in a lesser degree, probably learnt from the Spanish master.

"Of nothing too much", said the Greeks, a phrase in itself implying balance. And of balance itself one may have too much, and thus destroy character—easily in colour combinations (as I attempted to show in the last article), and also in tone; but I think more paintings err on the side of exaggerated all-over brightness or darkness, the former being very evident in much contemporary work. What I would stress is this: that the great masters of colour—above all, the Venetians, chiefly made use of the "cool" colours, and of spectral red (No. 1) a good deal brighter than that at the very end of the spectrum, and, in a lesser degree, of scarlet. The Dutchmen were fond of yellow, but even Vermeer, whose paintings are perhaps the most chromatic of any of them, used it with great restraint.

Beauty of tone was obtained, by the great colourists, as much by the use of well-balanced colour values, as by balance of light and shade; using the spectral hues very much at the same luminosity as that they possess in the spectrum, they gave to yellow and orange their full brilliance, and to the non-spectral hues their ominous darkness; but made sparing use of both the brightest and darkest chromata. Violet they employed scarcely at all, unless softened to lavender.

Quality in colour, like timbre in music, has to do with purity on the one hand, and complexity on the other. The purer the colour, that is, the freer it is from white light, the more saturated, stronger, and deeper is its tint.

James McNeill Whistler. A self-portrait

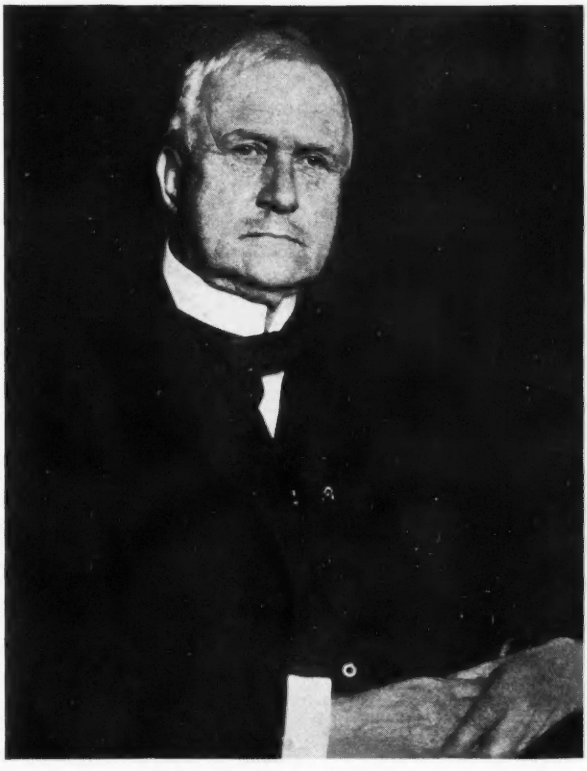
The very same musical note sounds different played on different instruments; and different again when sung, though the loudness is equal in each case. Even an untrained ear will detect these differences, which are due to the number, order and relative intensities of the note's harmonics or "overtones"—higher notes that a trained ear can detect sounding with, or immediately after, the fundamental note. And colour, too, has its overtones, though it takes a very delicate colour sense to detect them. Sometimes no eye can possibly do so, but the hue's impurity shows itself by its lack of strength, or tendency to neutrality. An identical yellow, for instance, to that in the spectrum, of the same wave-length, and exactly the same in appearance, can be formed by a mixture of red and green lights (of course I am not speaking here of mixture of pigments). In fact, any hue between purple and mid-green (5400 Ångström units), going clockwise round the colour circle, can be exactly matched by mixing two lights, of any wave-lengths between these two hues, in proper proportions. But this is not the case when lights of two hues, one of which is of *shorter* wave-length than $\mu\mu$ 540, are mixed. It follows, then, that light reflected from objects that appear violet, any hue of blue, blue-green, and jade and emerald green, must be very pure—coming in each case from one point of the spectrum only—and appears therefore very strong or saturated. Whereas the purples, reds, oranges, yellows and yellowish greens are of a whitish or slightly neutralized nature.

Here it is very important to distinguish between, on the one hand, darkness, or a tendency towards blackness, and its opposite, luminosity; and, on the other, saturation or strength, and *its* opposite, weakness of tint—which I, for convenience's sake, would call pallor (though the words "dark" and "pale" are often opposed in common talk—hence confusion of ideas). Fromentin, quite truly, writes: "Telle teinte très foncée peut être extraordinairement lumineuse; telle autre très claire peut, au contraire, ne l'être pas du tout." Souriau, quoting this passage in his book *L'Esthétique de la lumière*, cites an orange that had fallen into snow, and that, instead of looking darker by contrast, shone like a sun. "Foncé", in the passage from Fromentin, should of course be translated "deep" or saturated, and "clair" weak in colour or "pale"—inclined towards whiteness or neutrality. This is a subtle matter; for, in the spectrum, the most luminous colour—yellow—is also the least saturated; and violet is both the darkest and the strongest hue. But, except that they coincide at these two points, the luminosity and saturation curves are shaped differently.

As already noted, I think the masters of colour used hues very much as they appear in the spectrum, as regards brightness and darkness or "values". But, as regards saturation, they seem to have introduced modifications. The range from purple, through red, to mid-green, I think they usually employed at full strength. Weak oranges and yellows are disagreeable, and pinks and mauves mawkish. (One must make an exception in favour of the beautiful mauve-pink of the gown in Gainsborough's "Mrs Lowndes-Stone" in the Gulbenkian Loan Collection at the National Gallery; but how carefully he neutralized his background in that painting, causing a misty effect as of a dream, which a strong purple in the dress would have dispelled.)

The warm green, 5 in my list, of the Venetian triad is a beautiful hue as used by them, i.e. at full saturation; but extremely sickly when mixed with white. The hues 6 to 10 both inclusive, on the other hand, are harsh and cold unless modified and softened by the use of "broken colour". It is partly on account of their fondness for strong blues and violets, and acrid greens, that the colour of the Pre-Raphaelite School is so unpleasant. How different these hues become when broken with paler tints, or mixed with white—in fact, treated as they are in the works of the great Impressionists and their followers—or, for that matter, in Nature. What a delicate

shimmering blue is that of the sky, even in hot countries, infused with light and full of air; no idea of this can possibly be given by a hard coat of even paint. And how enchanting is the whole range of pale blues and of the tints between blue and grey—cloud-like colours—especially in the hands of Manet (in, for instance, "Le Linge", exhibited a few years ago in a Winter Exhibition at Burlington House), and Wilson Steer. Going back one hundred and fifty years or so, one may mention a charming picture by Copley, at Buckingham Palace, of some child-Princesses, full of delicious pale cyan-blues, unfortunately backed by a hard unnatural sky devoid of any sky- or cloud-colour. How exquisite, too, are the pale cool greens of Spring, which Camille Pissarro dared to transfer to canvas (see his "Printemps, Louveciennes" in the Tate Gallery). Sisley does so, too, with fine effect in "Petits prés du printemps", in the National Gallery.



Mr P. Wilson Steer, O.M.

Violet, the most difficult of hues, is very little used by the Colourists. But, mixed with white, it becomes lavender—a delightful colour, often used by Gainsborough. The general effects of strengthening the warm, weak hues and of weakening the strong ones (the cold hues and violet) are two: unity of quality, and warmth of colouring.

It is impossible completely to separate quality of colour from "quality of paint", as the former depends, in a slight degree, on the latter. Impossible, too, to avoid all mention of technique while on this subject. One may note how the Venetians worked:* they prepared their canvas, first probably with gypsum, then with a ground of half-tone in resin-oil paint, the colour either grey or reddish (the Dutch sometimes used an orange ground). On this, using a mixture of stiffly ground oil-colour and egg tempera, they under-painted in tinted whites. Strong colour was glazed, i.e. used in a more or less transparent condition, over this pale under-painting, the medium being resin-oil. I think these glazes account for the glow, and the look of "inner light" in Venetian pictures; for, in glazes, the light has penetrated and returns again to the surface. Rubens's pictures have not this appearance of "inner light", nor have

* Most of this description is taken from Herr Doerner's *Materials of the Artist*.

they the look of mysterious depth that we see in Titian's best paintings, and Velazquez's, who learnt much from the Venetians. The Flemish master has fine colour, but it all seems to be on the surface. As Reynolds said: "His colouring is too much of what we call tinted." Is this owing to his (Rubens's) practice of leaving his ground, a neutral grey, uncovered in the shadows?

Much work produced of late years has the look of tinted drawing, rather than of painting; and many oil paintings are executed after the manner of water-colour, as though the artist had chosen a medium for which he was not fitted.

The Great Colourists

I think the painters who excelled in colour have, as a rule, by no means without exceptions, used a fairly thick all-over impasto. The Venetians, the Dutch, more especially Rembrandt (who, when jokingly told that his portraits could be lifted up by the nose, replied that he was not a dyer but a painter), Velazquez, Watteau, Reynolds, Turner, Constable, the Impressionists, Cézanne, Steer, have all done so. Two contemporary painters, both excellent colourists, Maurice Utrillo and Richard Eurich, follow their example. Monticelli, a much-neglected nineteenth-century painter, whose colour had extraordinary beauty, loaded his canvas with something like an inch of paint, using, I am told, palette-knife far more often than brushes, and glazing over his heavy opaque impasto, in Old-Masterly fashion, with transparent pigments of pure deep hues. As a result, the quality of his colour is like that of stained glass and precious stones.

As I said, this rule, like every other, has exceptions. The principal ones, in temporal order, are the Orientals—Gainsborough, Whistler (who was greatly influenced by the Japanese), and, in our own time, Walter Sickert. In their works the canvas is allowed to be seen; but, being good colourists, they have known how to prepare their ground so as to blend with the thin covering of pigment and produce the desired effect.

A technical experiment which must greatly interest all who care for colour is that nick-named "Divisionism" or (in its more extreme form as practised by Signac and others) "Pointillisme". It was the practice of the great Impressionist Claude Monet, especially in his later work, to paint in separate touches of "pure colour" —chromata—mixed with white only, laying them side by side with no previous mixture on the palette. He did this with intense feeling for the subject, and great technical skill, and so produced marvellous effects of shimmering sunlight and of vibrating heat-haze, and a live, scintillating quality of colour that rivals that of Turner's best work.

Seurat reduced this process to a mathematically precise system—one can see the beginnings of it in his "Baignade" in the Tate Gallery, where only the shadows consist of juxtaposed spots of colour. Later, he carried this method to an absurd length, covering his canvas with small round dots of red, yellow and blue, the proportion of dots of each hue varying as required. We see the disastrous effect of this system in the most unpleasant gritty and chalky quality of his "Poudreuse" in the National Gallery.

Signac, in all his works, I believe, followed Seurat's example (thus wasting great talents and a strong natural colour-sense). So did Van Rysselburgh, but luckily in his case taste overcame science; and his pictures approach those of Claude Monet in truth of colouring, in brilliance, and in sense of atmosphere.

Degas struck out a line of his own, varying his style to suit his subject; sometimes he practised "Divisionism", laying on "pure colour" in large stripes and dabs, curiously coarse on close inspection, but so cleverly varied, both in form and hue, as to produce the desired optical blend at a distance. At other times he mixed his paint on the palette, as in our "Répétition" at

the Tate Gallery, a picture most delightful in quality of colour.

Of course, this awkwardly named "Divisionism" was no new thing in the Impressionists' time. Even in so early a painting as Velazquez's "Boar-Hunt" (National Gallery), some of the effect is produced by spots of pure paint laid side by side, and blending at a distance. The same device was used, very occasionally and to a slight degree, by Gainsborough; continually and boldly by Turner, and by Constable in his latest period, and once in an earlier work, his "Sketch for the Leaping Horse" (Victoria and Albert Museum), very much finer than the finished picture, owing partly to the fresh and lively effect of the unmixed pigment. The method was not always, however, an unqualified success in Constable's hands; with all his poetic imagination and fine sense of composition, he never quite acquired the necessary manual dexterity. But the works of the other men I have named owe much of their pure and fresh appearance to the juxtaposition of unmixed pigments. The fine quality of Cézanne's colour is due to the same practice; so is the brilliance and purity of Van Gogh's, whose colour, however, suffers occasionally from the poor and "scratchy" quality of his paint.

When all is said (by the critics) and, more importantly, done (by the painters), quality of colour is an elusive thing. It must be like the "timbre" of a Blüthner or Bechstein piano, pure, yet not too thin (not, as it were, flute-like, devoid of overtones); rich and opalescent, and without the muddy appearance that comes from too much mixing.

* * *

I have not mentioned various, but most interesting points, such as, for instance, how the great Colourists treated reflected light, and, in general, the effects of one coloured object on another. The Impressionists, and their followers over here, such as Wilson Steer, Orpen, and Henry Tonks (all of whom are represented in the Tate Gallery), made a special study of these things.

All such matters are as worthy of note by the student of pictures as by the painter himself, and will afford immense pleasure and interest.

If the technique of the thing (by the study of sketches, and unfinished parts of pictures) becomes easier to grasp, so much the better; and the student is on the way to become a painter. But only, as it were, a few inches along it, for it is a complicated business. Yet it is an infinitely delightful one; and so is this picture-gazing. And the delights of both are enormously enhanced by some slight knowledge of the wonderful unseen scaffolding on which are built up all the glories of colour, both in nature and in great works of art.

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Notes of the Month

The Problem of Cancer

SEVERAL stimulating suggestions are just appearing on cancer.

1. Dr D. B. Cruickshank of the Simms Woodhead Memorial Laboratory at Papworth has attempted to explain the fact that in this country the decrease in deaths of adults from tuberculosis has been exactly compensated by the increase in deaths from cancer. This fact is established by reliable statistics. Dr Cruickshank sets about explaining it by the idea of a "phage", which destroys the tubercule bacillus—but which destroys it in such a way as to become a cause of cancer itself.

The idea began by being no more than a suggestion. But the evidence for it now consists of intricate statistical investigations, and the facts are very striking, even though the case is still not proved.

2. Research on the biological effects of radiations is still proceeding fast. Tumours have been both produced and cured in rabbits by varying doses of X-rays. It has been confirmed that, in curing the tumours of mice with X-rays, treatment with split doses is more effective than a single exposure. This principle is being extended to human beings. At Mount Vernon Hospital patients are treated by this "stop and go" method, in which the tumours are frequently examined and only treated when they are thought to be sensitive to radiation. The intervals between treatment are sometimes as great as five weeks.

3. The causes of the disease appear to be complex, and no cancer virus has yet been isolated as a chemical entity. But a virus which produces a certain kind of tumour in chicken has been recently obtained almost pure. On the other hand, there is the puzzling fact that these same tumours can be induced by chemical means in the complete absence of the cancer-producing virus.

4. Cancer-producing chemicals are themselves being subjected to active research. Many have been discovered which are more active than coal tar, and a new one, 9 : 10-dimethyl–1 : 2-benzanthracene, has been found to be the most active carcinogenic compound yet known.

The Origin of the Great Nebulae

PROFESSOR GAMOW, who is known to readers of *Discovery* as the author of "Mr Tompkins in Wonderland", has just produced a fascinating suggestion upon the subject of the expanding universe. He and Dr Teller accept the commonly held theory that the system of great nebulae is at present in a state of uniform expansion. They make other simplifying assumptions. As a result they calculate that

about a thousand million years ago all nebulae were side by side, i.e. space was uniformly filled with stars. This epoch should thus be considered as the epoch of the formation of the stellar accumulations which we call the great nebulae.

It is worth remembering that, on geological grounds, the age of the earth cannot be less than a few thousand million years. One of the difficulties in most cosmological theories is that the age of the earth keeps turning out to be greater than the age of the universe.

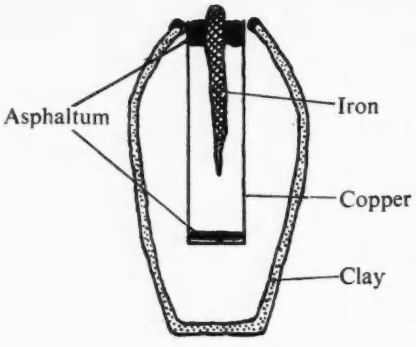
The Association for the Advancement of Science at Canberra

IN his presidential address to the Twenty-fourth Congress of the Australian and New Zealand Association for the Advancement of Science, which was held at Canberra in January, Professor Ernest Scott, Professor of History in the University of Melbourne, surveyed the achievements of science in Australia, from the botanical and zoological discoveries of the early explorers, to the industrial research of the present day. He recalled the time when Australia was so backward in the use of scientific training that scarcely one man of science was employed in industry. To-day, he said, the science schools of the Universities were unable to turn out completely trained men fast enough to meet the incessant demands of industry.

Referring to what he called "that strange little animal of zoological perversities", the Platypus, Professor Scott said, "the Platypus is a historical character. It set the anatomists all agog when specimens were first examined in Europe. It seemed illogical, self-contradictory, impossible, yet there it was, an amphibious creature which nests in a burrow, has a duck's beak, a mole's fur, webbed claws, spurs equipped with poison glands; it can growl, while the female of the species lays eggs and suckles her young." The animal was not described until about ten years after the foundation of the first colony. After its structure and organs had been examined, Sir Everard Home, Vice-president of the Royal Society, ventured the opinion that it was an egg-laying animal, but seventy-three years had elapsed between his conclusion and the discovery of the eggs of the Platypus after laying. That fact, said Professor Scott, illustrated in a striking way, the slowness with which scientific research developed in Australia in the period before the founding of the Universities.

An Electric Battery of 2000 Years Ago

THERE is strong reason to believe that electric batteries were actually known and in use long before the time of Volta and Galvani. To the men who built them, it was only an empirical knowledge that they could expect certain results if they did certain things. It might be added at once that this empirical knowledge seems to have been confined to narrow boundaries, the centre of which was the famous old city of Baghdad.



Doctor Wilhelm Koenig of the Iraq Museum in Baghdad reported recently that a peculiar instrument had been unearthed by an expedition of his museum. The find was made at Khujut Rabu'a, not far to the south-east of Baghdad, near the railway leading to Kirkut. It consisted of a vase made of clay, about 14 cm. high and with a largest diameter of 33 mm. Inside this vase a cylinder made of sheet copper of high purity was found, the cylinder being 10 cm. high and having a diameter of about 26 mm.

The lower end of the copper cylinder was covered by a piece of sheet copper of the same thickness and quality as the cylinder itself. The inner surface of the round copper sheet, the surface that formed the inner bottom of the hollow cylinder, was covered with a layer of asphalt, 3 mm. in thickness. A thick and heavy plug of the same material was forced into the upper end of the cylinder. The centre of the plug was formed by a solid piece of iron, now 75 mm. long and originally a centimetre or so in diameter. The upper part of the iron rod shows that it was originally round, and, while the lower end has partly eroded so that the rod is now pointed at the lower end, it might safely be assumed that it was of uniform thickness.

An assembly of this kind cannot very well have any other purpose than that of generating a weak electric current. If one remembers that it was found among undisturbed relics of the Parthian kingdom (which existed from 250 B.C.–A.D. 224) one naturally feels very reluctant to accept such an explanation. The fact that four similar clay vases were found near Tel' Omar or Seleukia increases the value of this discovery. Three of these also contained copper cylinders similar to the one found at Khujut Rabu'a. The Seleukia finds were apparently less well preserved; there are also no iron rods in evidence. But close to these four vases pieces of thinner iron, and copper rods were found, and these may be assumed to have been used as conductive wires.

Similar "batteries" are also known from the vicinity of Baghdad from ruins of a somewhat later period. An expedition headed by Professor Dr E. Kühnel, who is now director of the Staatliches Museum in Berlin, discovered very similar vases with copper and iron parts at Ktesiphon, also not far from Baghdad. These finds date from the time when the dynasty of the Sassanids ruled Persia and the neighbouring countries (A.D. 224–651).

While the probable date of the invention is entirely open to conjecture it seems likely that it was made in or near Baghdad, since all known finds were made in the vicinity of this city. It must be assumed, of course, that the subjects of the Sassanids had some use for the "batteries" and Doctor Koenig, the discoverer of the best

preserved of all these vases, suggested that this use might still be in evidence in Baghdad itself. He found that the silversmiths of Baghdad use a primitive method of electro-gilding their wares. The origin of their method cannot be ascertained and it seems to date back a fair number of years. Since galvanic batteries of the type found would generate a sufficiently powerful current for electro-gilding small articles of silver, it might very well be that the origin of the present-day method has to be sought in antiquity.

It is, of course, strange that nothing of this remarkable feat has ever been related by an ancient author, but if the batteries and their use constituted a valuable trade secret in olden times it is possible that it was very closely guarded.

THE AUSTRALIAN FRILLED LIZARD

Quite harmless, in spite of its formidable appearance. Three feet long, including a long, tapering tail, which, however, cannot be seen in the photograph.

Photograph by Edward Samuel.

THE DISCOVERY OF QUININE

by

Hilda Herne

THE accepted account of the discovery of quinine is that a Spanish soldier who had fallen ill with fever in Peru was cured by a powder made from the bark of a tree and given him by his Indian friend. On his recovery, the soldier set about to discover the identity of the tree, in order to be able to get further stores of the bark which he realized would bring great relief to his comrades, many of whom suffered from lingering intermittent fevers. He actually did find the tree, and the story of his success as an amateur physician soon got abroad. When the Countess of Quinchona, wife of the Viceroy, was stricken with fever in 1638, the Corregidor of Loxa sent for the soldier and bid him demonstrate the harmlessness of his remedy by taking a dose himself in his presence and, then, being assured that it was not a poison, he ordered him to administer it to the suffering lady. She soon recovered. The wonder-working bark was called henceforth "The countess's powder". (It was the famous Swedish botanist Linné who first called it cinchona.)

A story, which is not so well authenticated but which may well be true, is that near Loxa there was a lake and, during an earthquake, several large trees near the bank were uprooted and fell into the water. An Indian who was accustomed to bring his cattle there to water them observed that beasts which were ailing speedily recovered their health after drinking from this spot. He himself was burnt with fever and drank of the water which he found extremely bitter. His fever left him and he gave himself no rest until he had found the agent of this cure. So quinine was discovered.

The first published work in praise of the virtues of quinine was the *Vera praxis ad curationem tertianae* by Pietro Barba, a Spaniard, physician to the Cardinal Infante Ferdinand, Governor of the Low Countries and brother of Philip IV.

It is a strange trait in human nature never fully to accept a new discovery without obstinate opposition. We have only to think of some of the common commodities of our ordinary life, coffee, tea, tobacco, chocolate, for instance, each of which in their day and often over a long period, roused storms of abuse, which might rise to anathema or fall to ridicule. Quinine was no exception. No sooner did a section of scientific opinion welcome the new fever cure, when an opposing section rose up and condemned it. In 1647 Colmenero, a convinced upholder of Galen's medical theories, published his *Reprobación del pernicioso abuso de los polvos de china-china*. So the battle commenced and continued in one country after another.

Independent reports began to be received from Jesuit missionaries, from traders and travellers, and one of these, Antonio Bollo, a Genoese merchant, sent a sample of the cinchona bark to Cardinal Juan di Lugo at Rome. The cardinal was the head of the Jesuit medical college there, and he arranged for the drug to be carefully tested. Its value was recognized and it was known as the "Pulvis eminentissimus cardinalis".

Cardinal di Lugo was first instrumental in introducing quinine into France, but there the medical faculty was extremely conservative, and the famous Guy Patin, enemy of all innovations, was not long in pouring forth the full stream of his witty invective against the "Jesuits' powder" which he said "had no effect whatever".

It was a simple English doctor named Talbot to whom falls the honour of popularizing quinine not only in England but also in France. Talbot had been a druggist's assistant in Cambridge, where he had become familiar with quinine and its indications. He established himself in medical practice in London, and began to specialize in the treatment of fevers, employing a remedy which he persisted in keeping secret.

Charles II was subject to attacks of ague. In 1680 he had an attack, and Talbot is said to have given him his remedy and to have cured him. That Charles had a high opinion of the efficacy of quinine is clear from a note made by Evelyn in his *Diary*, 29 November 1693: "I visited the Marquiss of Normanby and had much discourse concerning K. Cha. II being poison'd. Also concerning the *Quinquina* which the physicians would not give to the King, at a time when in a dangerous ague it was the only thing that could cure him (out of envy because it had been brought into vogue by Mr. Tudor an apothecary), till Dr. Short, to whom the King sent to know his opinion of it privately, he being reputed a Papist, (but who was in truth a very honest good Christian) sent word to the King that it was the only thing which could save his life, and then the King injoin'd his physicians to give it to him, which they did, and he recover'd. . . . Being asked by this Lord why they would not prescribe it, Dr. Lower said it would spoil their practice."

Sydenham was at first inclined to doubt the virtue of quinine, but he finally accepted it as a specific and called it the "arbor vitae".

His success at court may have given Talbot the idea of going to France. He was extremely well received there by the wife of Coligny, by Richelieu and by Madame de Sévigné among others. Louis XIV often suffered from fever, and we read how on several occasions he received doses of quinine, in 1686 in burgundy and in 1687 in pills taken in apricot jam.

Talbot began to make a large fortune and finally Louis XIV, recognizing the value of the medicine, bought the secret from him and made it public so that all his subjects would be able to benefit from it.

Among Talbot's many friends was Nicolas de Blegny, who published several small works dealing with the new remedy. The title of one of these reads: *La découverte de l'admirable remède anglais pour la guérison de fièvres*, Paris, MDCLXXX.

Talbot's general prescription was as follows: "Take a pound of good quality cinchona bark, finely powdered, sprinkle it alternately with a decoction of aniseed and parsley juice for one or two days, then put the powder in a stone jar (of about 15 pints' capacity), pour gradually as much red wine as will fill the jar, cork tightly, let stand for 8 days, away from the fire. Stir well two or three times daily with a clean stick. Decant into glass bottles which must be well stoppered. Keep in a dry and not too airy place. Thus prepared, the infusion will keep for 2 or 3 months or even longer."

He also prepared infusions containing rose leaves and lemon juice, generously mixed with wine, to mask the bitter taste of the quinine, and sometimes including opium. La Fontaine wrote a little playful ode in honour of Talbot in which he lightly alludes to the non-teetotal character of the English Aesculapius's medicine:

"Les médicins sont aux abois
Et ne savent que dire;
Le nouvel Esculape anglois
Est venu les détruire.
Purger, lavamenter, saigner,
Et prêcher l'abstinence,
C'est ce que savent ordonner
Les médicins de France.
Talbot sera mon médicin,
Puisqu'il veut qu'on boive du vin...."

But quinine was sometimes given otherwise. The following note appears in the journal of the apothecary, Matthieu François Geoffroy: "Le jeudi-Saint 23 mars [1690] j'ai été à Versailles par ordre du Roy et du Monseigneur [Grand Dauphin] où j'ai fait prendre à Mme la Dauphine en présence du Roy de l'extrait de quinquina en petites pilules dorées."

A sidelight is thrown on the manners of the doctors of the time and on Talbot himself in the following passage from de Blegny's book:

"A man of quality falls ill with tertian fever. A doctor of the Faculty is sent for. He comes in handsome attire, looks at the patient with a grave air, reasons on the movement of his pulse, defines his malady for him by all the rules, explains its causes and its accidents and describes its probable course, according to the doctrine of Hippocrates, from whose works he recites two or three aphorisms in Greek. He confirms his statements by quoting twenty passages from Galen in the most beautiful Latin in the world. All this to prove that the fever is caused by a vapour which is exhaled at regular intervals by the pancreas, the seat of putrefaction. As a cure he prescribes little irrigations, harmless, refreshing and soothing, to extinguish the fire consuming the entrails, two or three bloodlettings to correct the putrefaction of the blood, several purges to expel the impure and fetid matter.... But the fever grows worse and now is double tertian. They send for the English doctor. He is just like ordinary men. He says he knows no Latin and no Greek, that long speeches have never cured any ill, but that his remedy will cure the patient without trouble, and in a very few days. The remedy is administered a few hours before the next attack. It lessens the severity and the violence of the crisis. The next day the patient has a much lighter attack and the day after he is quite free from fever."

SECRETS
CONCERNANT
LA
BEAUTE' ET LA SANTE'

DEUXIE'ME PARTIE.

Contenant la description du Remede Anglois, publié par l'Auteur suivant les Ordres du Roy; avec les Observations de Monsieur le Premier Medecin de Sa Majesté.

Premiere Infusion du Quinquina, faisant partie du Remede Anglois.

The first page of "Secrets concernant la beauté et la santé" by Nicolas de Blegny, 1680, with a description of the "Remede Anglois".

The picture on page 152 is from Pomet, "Histoire generale des drogues", 1694.

"*Just as the superstructure theory of philosophy is untenable so is the notion that science is based on philosophy. It is true that science is based on a theory of a very general kind, but this theory is used for practical reasons and not on account of its plausibility to philosophers. In spite of recent attempts to set up idealism in place of the matter-of-fact view that there is an external world of things which we know through our senses, it cannot be said that the materialistic conception has ceased to permeate the manner of thought of scientists.*"

W. H. WATSON in *On Understanding Physics*

Letters from Readers

Small Eggar Moth

IN the February issue of *Discovery* there is an excellent photograph of a specimen of the Small Eggar moth (*E. lanestris*) just emerged from its cocoon, and drying its wings. A peculiar feature is that the photograph "A" below shows a hole in the *side* of the cocoon. *E. lanestris* normally emerges through a circular hole at one *end* of its cocoon. This can be seen clearly from the cocoon shown here, "B", which still has the circular cap attached to one end. It would be interesting to know whether the hole in the side of the cocoon shown in the photograph was made by natural or artificial means.

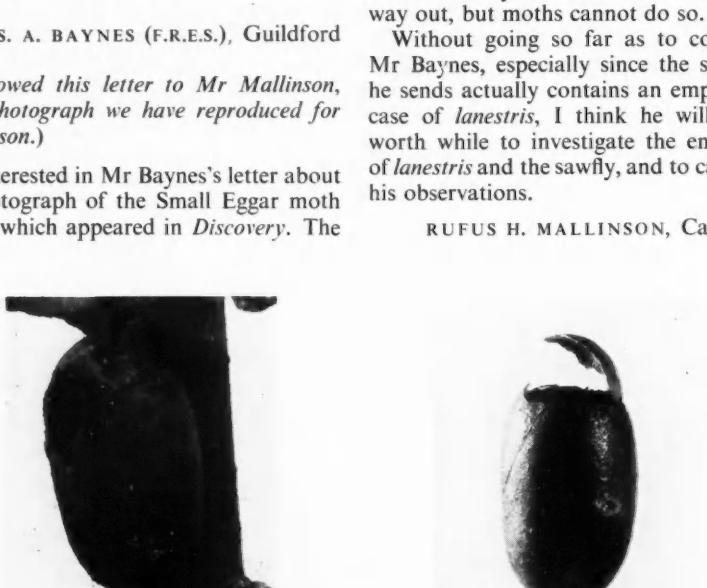
E. S. A. BAYNES (F.R.E.S.), Guildford

(*We showed this letter to Mr Mallinson, whose photograph we have reproduced for comparison.*)

I AM interested in Mr Baynes's letter about the photograph of the Small Eggar moth cocoon which appeared in *Discovery*. The cocoon was the actual one from which the moth had emerged, and the hole was made by the moth. When Mr Baynes speaks of a "circular hole and cap", the hole and cap obviously cut uniformly and cleanly round the cocoon, he might seem to be confusing the Eggar with the well-known sawfly, *Trichiosoma tibialis*, whose cocoon is extremely like that of *E. lanestris* and is also found on hawthorn. This sawfly is able to cut a circular cap from the end of the cocoon, and always does so, but no species of moth can cut a circular cap, moths being compelled to *push* their way through the fabric of the cocoon, usually after softening it in some way. Ichneumons also cut their way out, but moths cannot do so.

Without going so far as to contradict Mr Baynes, especially since the specimen he sends actually contains an empty pupa case of *lanestris*, I think he will find it worth while to investigate the emergence of *lanestris* and the sawfly, and to catalogue his observations.

RUFUS H. MALLINSON, Cambridge



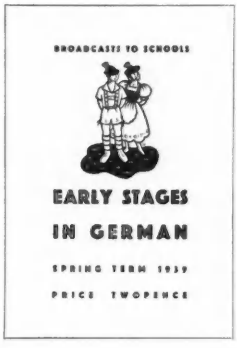
A *B*

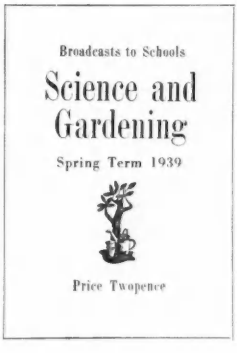
On the left is Mr Mallinson's photograph, showing the hole at the side of the cocoon. On the right is a photograph taken of the cocoon sent by Mr Baynes. The length of the actual cocoon is just over half an inch.

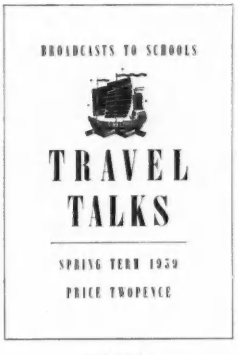
Broadcasting for Schools

By G. H. VALLINS

THERE was a time when the teaching profession was quite alarmed at the possibilities of broadcast "lessons" for schools. Some pessimists even went so far as to predict a state in which about a dozen specialists would control education from Broadcasting House, and the loudspeaker would oust from the schools all but a few teachers necessary for the organization and discipline of classes they would never be called upon to teach. Fortunately for everybody concerned, their prophetic fears have not been realized. School broadcasting has settled down to the limitations imposed upon it by the existing order of things. The B.B.C. itself obviously cannot afford more than a very limited amount of time daily for so specialized a service; and the schools, with their complicated and often overcrowded timetables, can, in the very nature of things, take advantage of the broadcast lesson only as an auxiliary to their ordinary work. In other words, the loudspeaker has taken its rightful place, as complementary and not antagonistic to the teacher. Theoretically, at any rate, all is as it should be; the schools, and the teachers, have everything to gain and nothing to lose from a system that affords them a good and varied service with the minimum of interference.







A brief study of the latest pamphlets outlining the programme of lessons in various subjects for the Spring term reveals, however, certain weaknesses and difficulties that have yet to be overcome. Naturally the most valuable broadcast lessons are those in which the aural effect is paramount—that is to say, the lessons in foreign languages and music. By most of the teachers who use them these are considered a valuable aid. But with the other subjects the problem of continuity creeps in. It is true that in History, Geography, and certain Sciences (especially Biology), the B.B.C. scheme has a continuity of its own. Thus the general scheme for the lessons in History during the Spring term is "Change and Expansion, Fifteenth to Nineteenth Centuries". But the actual lessons are so limited and arbitrary in subject that it is difficult to see how they can be profitably grafted on to a normal school course, where progress on the study of a period is necessarily slower. No doubt there is much to be said for a course which has a unity of theme and a wide sweep of interest; but it is achieved by a disconnected scrappiness of treatment that does not easily fit in with the more detailed methods necessary to ordered teaching in the classroom. In English, where continuity

seems to be flung overboard in favour of diversity, things are rather worse than better, mainly because the subjects chosen are too often wide of the mark or, not to put too fine a point upon it, feeble in their appeal to children. In this matter, and some others, the Council for Educational Broadcasting might learn a lot from the surer methods of the Children's Hour.

The practical difficulty of the adjustment of the school time-table to the periods of broadcasting is always acute, especially in secondary schools, where, owing to the prevalent specialist system of teaching, the times of individual lessons are necessarily fixed and rigid. Indeed, it may be said that in many secondary schools the use of broadcasting is automatically ruled out on this ground alone. It is obviously impossible to take, for example, a broadcast lesson in French from 3.35 to 3.55 if those twenty minutes happen to fall within the time of two consecutive periods, devoted to different subjects, in the school time-table. For this reason, it would seem that the secondary schools would be better provided for if there were fewer but longer broadcasts, preferably with dramatic interest, suitable for whole sections of the school assembled for the occasion in the school hall. There are probably serious educational objections to this method. But as it is, the secondary teachers, with the best will in the world, find it impossible to avail themselves, except on rare occasions, of the fare provided. It is, by the way, an odd and ironic fact that in the month of July, when, after the annual internal and external examinations, the time-table is more easily adjustable and teachers would most welcome an outside stimulus, broadcasting for schools is discontinued altogether.

One problem, often only dimly recognized, lies in the sophisticated attitude of a generation of children to whom broadcasting has become a familiar element in everyday life. Lessons from the studio have, too often, a faintly patronizing air. More and more the child likes, in his listening, to become a man, and to put away what he thinks to be childish things. Some teachers, accordingly, ignore the school broadcasts altogether, and content themselves with recommending to their classes the items in the week's ordinary programmes that have educational value and interest—like the performance of a well-known play, or the reading of the News in various foreign languages, or a programme with some bearing on, say, History or Science. And there is much to be said for it, especially if the broadcasts are followed up next day with discussion and commentary. In fact, it might almost be argued that intelligent listening outside school is, fundamentally, far more valuable than compulsory listening to the more or less *ad hoc* lessons broadcast in the present educational scheme. But this is a big question; and the future of school broadcasting is, of course, closely bound up in it.

Granted the present system, one other question arises. It may be put quite briefly. Why cannot the microphone be brought to the classroom, as it is brought to the pulpit? There must be teachers up and down the land competent to broadcast from their native heath lessons that would be welcomed by their confrères in other schools. Probably the idea bristles with difficulties both professional and technical; but surely it is not quite impracticable. At any rate, it might be tried.

"*The reality created by modern physics is, indeed, far removed from the reality of the early days. But the aim of every physical theory still remains the same.*

"*With the help of physical theories we try to find our way through the maze of observed facts, to order and understand the world of our sense impressions. We want the observed facts to follow logically from our concept of reality. Without the belief that it is possible to grasp the reality with our theoretical constructions, without the belief in the inner harmony of our world, there could be no science.*"

EINSTEIN and INFELD in *The Evolution of Physics*

An Introduction to Botany

THE method of introducing botany to the beginner at Leeds University is based upon an intimate study of the flowering plant in all its aspects, but emphasis is laid more upon development, as an interpretation to form and structure, than upon function. At the outset the student is taught to associate growth with increase in dry weight. Formation and development of organs, including growing points, are investigated as far as dissecting needles and a hand lens will permit, which naturally leads to further study with the aid of the microscope. The deductions which can be made from what is seen with this instrument are rightly emphasized. Staining of sections cut in various planes supplemented by maceration of tissues forms no small part of the student's training, and he thus comes to realize that a plant is built up of various tissues developing from cells originally alike. The investigation of leaf formation and structure introduces metabolism, but before photosynthesis and respiration are dealt with a stimulating chapter is interpolated on the carbon atom, carbohydrates, fats and proteins. The structure of roots prepares the way for a consideration of the means of entry of water and inorganic solutes, the fascinating subject of special nutrition in flowering plants receives attention, and fungi, as parasites and saprophytes, afford opportunity for introducing methods of sterilization and pure culture. These, however, are not quite up-to-date: it is *not* necessary to flame cotton wool plugs before withdrawing them, but it *is* essential to flame the rims of the tubes. In the strictly orthodox account of the origin and development of the carpel no indication is given of the challenge to this view put forward by Miss Saunders, and in the brief account of life cycles of some typical vascular and non-vascular plants no mention is made of the striking difference in structure of the two types of growing points. In this section emphasis is placed upon the constant nature of the gametes throughout these types. A short account of the nucleus and of heredity is introduced towards the end of the book, which closes with the biology of flowers and fruits, and the principles of classification in which the student is well advised to do two things: make a collection of plants, and study a few families thoroughly.

The book* is written in an attractive style singularly free from ambiguity, and has the additional recommendation that practically all the illustrations are new. These consist of well-reproduced photographs of macerated tissues and the really beautiful drawings of Miss Malins, without which the work would be lacking in some of its charm and power to arouse interest in the study of plant life.

W. J. D.

* *An Introduction to Botany*, by J. H. Priestley and Lorna I. Scott. Longmans, Green. 17*s.* 6*d.*

Galileo and the Freedom of Thought

THIS is a very interesting book† which should be read by all students of physics. It will be appreciated and enjoyed too by all who are interested in the history of thought, and the lack of a knowledge of physics will cause slight difficulty only in one or two isolated places.

Many delightful quotations illustrate Galileo's clear thought and his powers of exposition, and make one wish that the whole of the excellent translation of the *Dialogues Concerning the two Principal Systems of the World* made by Thomas Salusbury in 1661–5 could be reprinted so as to be easily accessible. They also make it easy to understand that Galileo's clear and incisive style would irritate his opponents. These opponents consisted in part of other mathematicians and philosophers and in part of the leaders of the Church. All the teachers in the Universities had been brought up in the Aristotelian tradition and accepted the Ptolemaic theory of the universe with a fixed earth at the centre. This

† *Galileo and the Freedom of Thought*, by F. Sherwood Taylor. Watts. 7*s.* 6*d.*

theory was actually in a highly developed state; for example, the elaborations necessary to take account of the motions of the planets were fully worked out. Self-interest made these teachers want to uphold the old tradition which they had always taught, but Galileo was quite capable of dealing with them and he appears to have enjoyed a fight.

In a short preface the author points out that this study has a very different interest for us to-day from what it would have had twenty years ago. This is unhappily true, for tyrants now dominate large areas in Europe. It is important to remember that it is not one particular institution which throughout the ages remains the enemy. Whenever the spirit of oppression arises it must be fought, and it takes different forms and uses different institutions at different times. In Galileo's day it was the Inquisition and the Roman Catholic Church, while in ours an Archbishop of that same church is one of the bravest opponents of this spirit.

Censorship in one form or another is not on the decline in our own land which has for so long been the home of freedom. It must be realized that at all times criticism and truth have been feared only by the inefficient and those in an untenable position, and that these people have always found some high-sounding reason for suppressing them, be it the interest of their religion, their race or their country. Scientists may be tempted to say that any increase in censorship and authoritarianism is not likely to affect them. Experience does not support this view. Truth is one and indivisible and so is freedom, and an attack on them in any one direction should rally all who respect them to their defence. J. K. ROBERTS

Select List of Books Received by *Discovery*

(*Mention in this list does not preclude review*)

Builders of Health. DAVID DIETZ. (George Allen and Unwin, 12*s.* 6*d.*)

Medicine in Modern Society. DAVID RIESMAN. (Princeton University Press, 11*s.* 6*d.*)

Textbook of Heat. (Second Edition revised.) R. W. STEWART and JOHN SATTERLY. (University Tutorial Press, 7*s.* 6*d.*)

An Introduction to Vertebrate Anatomy. H. M. MESSER. (Macmillan, 16*s.*)

Iceland Papers. Vol. I. (Oxford, 21*s.*)

Trade Marks. REGINALD HADDON. (Pitman, 5*s.*)

Working Diagram Models. H. R. LANGMAN. (The Technical Press, 3*s.* 6*d.*)

Birds of Tropical West Africa. Vol. V. DAVID BANNERMAN. (Crown Agents for the Colonies publication, 22*s.* 6*d.*)

The Genetics of Garden Plants. M. B. CRANE and W. J. C. LAWRENCE. (Macmillan, 12*s.* 6*d.*)

The Factorial Analysis of Human Ability. GODFREY H. THOMSON. (University of London Press, 16*s.*)

The photograph of Guillemots and Kittiwakes appearing in our February number was the copyright of Mr H. N. Southern.

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